DYNAMICS OF NORTHERN PIKE SPAWNING AND NURSERY HABITAT IN THE YAMPA RIVER, COLORADO

Upper Colorado River Endangered Fish Recovery Program

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EXECUTIVE SUMMARY

Reduction of northern pike has been identified as a key step in the recovery efforts for endangered fish in the Yampa River. We evaluated the effectiveness of barriers to backwater spawning habitat as a way to limit northern pike *Esox lucius* spawning success and thereby reduce recruitment. Potential backwater spawning habitat appeared to be abundant in the Yampa River, but high quality backwaters were limited. The majority of backwaters showed signs of receiving flushing flows during spring runoff, which calls into question the quality of backwaters as nursery habitat. Few age-0 northern pike were found in backwaters. Age-0 pike were much more abundant in samples from one off channel pond, suggesting that these areas may be a more significant source for young-of-the-year recruitment. In addition, northern pike movements from a reservoir to the Yampa River were documented. Fall installation of barriers was not effective because of damage from ice during the winter. Spring installation is feasible, but would need to be done in the limited amount of time before northern pike begin to spawn. The reluctance of some land owners to allow barriers to be installed on their property and the apparent low recruitment found in backwaters suggest that the time and money spent on installation may not be worthwhile. Future studies and management should be directed at the ponds and reservoirs, which appear to be important sources of northern pike recruitment into the Yampa River.

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Introduction

Northern pike (*Esox lucius*) in North America are native to the Missouri River drainage, the upper part of the Mississippi River drainage, parts of the Ohio River drainage, Alaska, and Canada south of the Arctic Circle (Crossman 1978). Since 1850, the distribution of northern pike has expanded beyond their native range and they are now widespread throughout North America (Crossman 1978). The development of numerous impoundments has provided the opportunity for many intentional and illegal introductions (Fuller et al. 1999). The reason for most northern pike introductions has been to create new sport fishing opportunities, but they have also been introduced to control populations of abundant prey species (Mann 1996).

Introductions of northern pike in some areas have hampered fishery management actions resulting in serious losses to local and regional economies. Previously productive trout reservoirs in some areas have become so dominated by northern pike that stocked trout no longer show up in angler creels (Bergersen 2001). Introductions of northern pike in Lake Davis, California and south central Alaska pose a potential threat to commercial salmon fisheries near these areas. Northern pike escapement from impoundments to downstream rivers that contain threatened and endangered fish adds an additional threat to the recovery of threatened and endangered fish (Tyus and Beard 1990). Attempts to eradicate northern pike from reservoirs and drainage basins have met with little success (Bergersen 2001; California Department of Fish and Game 2000).

In contrast, northern pike populations within its native range are declining due to loss of spawning and nursery habitat (Casselman and Lewis 1996). Typical northern pike spawning habitats in rivers are marshy areas connected to rivers (Bry 1996). The timing of spawning is highly variable throughout North America and has been noted to take place anywhere from February to June (Billard 1996). Northern pike typically spawn at water temperatures of 7.8 – 11.7° C soon after ice-out (Casselman and Lewis 1996; Farrell 2001), but may enter spawning areas at temperatures as low as 0.6 – 4.4° C (Franklin and Smith 1963). Individuals typically spawn over a period of 5 or 6 days, but low temperatures can extend the spawning period to as many as 19 days (Franklin and Smith 1963).

The Yampa River is home to the Colorado pikeminnow (*Ptychocheilus lucius*), humpback chub (*Gila cypha*), bonytail (*Gila elegans*), and razorback sucker (*Xyrauchen texanus*), which are currently listed as federally endangered species. As a relatively free-flowing river, it is an important area for efforts to recover these endangered native fish. The section of the Yampa River downstream of Craig, Colorado (river mile 139) has been identified as critical habitat for threatened and endangered fish, and northern pike and other nonnative fish inhabiting this reach have been identified as major predatory threats to native fish (Nesler 1995). The northern pike's first arrival in the Yampa Valley occurred with its stocking in Elkhead Reservoir, a reservoir located on a tributary stream to the Yampa River. As early as 1979 northern pike escaped from Elkhead reservoir and have proliferated in the Yampa River ever since (Tyus and Beard 1990).

Trautman (1957) identified limited access to spawning areas as the main factor leading to a decrease in northern pike populations in Lake Erie. Where backwater spawning habitats have a single access point to the river, one possible approach for managing northern pike populations may be restricting access to spawning sites. The purpose of our study was to investigate northern pike spawning and nursery habitat in the Yampa River to determine whether barriers to spawning habitat could be an effective management technique for reducing northern pike numbers. To evaluate the effectiveness of barriers, we determined the timing of spawning, assessed the abundance and quality of spawning and nursery habitat, evaluated the effects of variable spring runoff flows on spawning and nursery habitat, and determined recruitment levels of age-0 northern pike. Our evaluation of barriers included assessing the effectiveness of different barrier designs and installation times, and determining the feasibility of installing barriers throughout the study area.

Goal and Objectives

Goal: to reduce spawning and reproduction by northern pike in Yampa River habitats, effecting a reduction in the abundance of pike in critical habitat for endangered fishes downstream.

Objectives:

1. To determine the feasibility and logistic requirements of using temporary screening with low-cost materials to prevent access to these habitats by spring spawning, adult northern pike on a reach-wide scale from Craig to Steamboat Springs.
2. To implement exclusionary screening of potential pike spawning habitats on a reach-wide scale and mechanically remove pike from any habitats where access by pike to screened spawning habitats has been gained due to temporary screen failure.
3. To monitor effectiveness of exclusionary screening of pike spawning habitats using trend analysis of capture rates for northern pike during ongoing mechanical removal efforts within critical habitat in the Yampa River downstream.
4. To evaluate and recommend design improvements in existing irrigation diversion and return systems to reduce potential northern pike spawning habitat or facilitate screening control.

Study site

The Yampa River is located in northwest Colorado and originates at an elevation of 2,287 m. It joins the Green River in Dinosaur National Monument near the Colorado/Utah border. The aquatic communities transition from coldwater to coolwater between Hayden (River mile 170) and Craig (River mile 139), Colorado, and from coolwater to warmwater between Craig and Duffy Mountain (River mile 118), Colorado (Nesler 1995). The Yampa River is a unique stream in the upper Colorado River basin

because it still maintains a normal hydrograph with natural spring runoff flows. Early April flows (April 1-15) at Steamboat Springs, Colorado, average 449 cfs and typically have been between 400 and 600 cfs since 1911 (USGS 2003). Spring runoff usually begins in mid May with long-term peaks averaging 1,734 cfs, (range: 700 to 3400 cfs).

The main channel is constantly reshaped and redirected because of natural runoff cycles leading to naturally occurring oxbow channels. Over time these channels are cut off with re-directed main channel flow to form side channels, backwaters, and eventually sloughs and isolated ponds. According to Gurtin et al. (2003), backwaters are permanent bodies of water that are connected to but physically distinct from the main channels or side channels. Backwaters on the Yampa River typically have emergent grassy vegetation along the bank, sometimes extensive aquatic vegetation, and little or no flow. In addition to backwaters, there are many oxbow lakes and gravel pit ponds located along the river that are typically isolated, but periodically connect to the river during flood events. In addition, some of these ponds have narrow outlets (a ditch, culvert, or small stream) connecting them to the river. Isolated sections of the old river channel, old side channels that have become backwaters, and off channel ponds are believed to be the primary spawning habitat for northern pike in the Yampa River (Nesler 1995). Additionally, large pike populations exist in Stagecoach Reservoir and Catamount Reservoir, which are reservoirs built on the main stem of the Yampa River above Steamboat Springs, and in Elkhead Reservoir.

Nesler (1995) identified the area around Craig and upstream as the major location of suitable backwater pike spawning habitats. Backwaters below Craig were less common and lacked abundant vegetation and usually became flowing side channels during increased spring flow periods. Nesler (1995) also concluded that northern pike found in threatened and endangered fish critical habitat areas below Craig originated in the better spawning habitats upstream. Our study focused on the Yampa River between Steamboat Springs and Craig (Figure 1). Primary backwaters studied were located at river miles 174, 163.8, and 163.3. One gravel pit pond connected to the river at mile 197 was also included in our study. This latter site had a shallow marshy area connected to the main pond, which in turn was connected to the river. Age-0 northern pike were collected at backwaters located at river miles 197.8, 197, 196.5, 174, 169.1, 163.8, 163.3, 155.3, 155, 154.4, 154.2, and 152.5. The backwater located at river mile 197.8 (Chuck Lewis State Wildlife Area) had two distinct spawning areas denoted as site A and site B. Sampling for age-0 northern pike at the gravel pit pond took place at the area where spawning adults were collected and also in the outlet stream connecting the gravel pit pond with the Yampa River (river mile 196.5). Depth gage readings and detailed habitat surveys took place at backwaters located at river miles 197.8 (A&B), 174, 169.1, 163.3, 155.3, 155, 154.2, and 152.5. Barriers were installed at sites located at river miles 197.8, 197, and 152.5.

Methods

Assessment of spawning and nursery habitat characteristics

During 2002, four sites were sampled to determine when northern pike were using the backwaters and when they spawn. A nylon seine with 38.1 mm mesh and leadcore bottom line was stretched across the mouth of each backwater with two trapnets attached to holes cut in the seine. Steel posts were installed on each bank and in the backwater to secure the seine and trapnets. One trapnet collected fish moving into the backwater and the other collected fish as they moved out of the backwater. Each northern pike caught was tagged with an individually numbered t-post tag, weighed (lb, oz), measured (in), checked for eggs or milt, and released in the backwater or in the main channel depending on the direction it was moving. The seine/trapnets were installed on April 9-16, 2002 and checked daily for five weeks.

Water temperatures were measured in the main river channel and in backwaters to determine temperatures associated with pike spawning activity. Temperatures were recorded with Onset Optic StowAway temperature loggers in the Yampa River at Steamboat Springs (river mile 197), near Hayden (river mile 169.1), and near Craig (river mile 137). Loggers were installed in the mouth of backwaters at river miles 174, 163.8, and 163.3 and at the gravel pit pond at river mile 197 in early April 2002 and remained in place throughout the study. Additional temperature loggers were installed at backwaters at river miles 197.8 and 152.5 in April 2003.

Aerial photographs taken September 5, 1999 were analyzed to determine the potential abundance of backwaters. The river was navigated by canoe from the west end of Steamboat Springs to Craig to identify the location and distribution of backwater spawning sites. A global positioning system was used to record the location of each backwater. Habitat measurements at each site consisted of length and width measurements, backwater orientation to the river, depth at mouth of the backwater, and evidence that the backwater became part of the flowing channel during spring runoff. Because spring runoff flows can seriously impact spawning habitat, we attempted to categorize possible backwater spawning areas not only by size, but also by orientation to the river and by visual signs that spawning habitat was exposed to flushing flows during spring runoff. The bank separating the backwater from the river was assessed for the presence of vegetation and bank composition to indicate whether the backwater became a flowing side channel or was simply inundated during spring runoff. The presence of vegetation and dirt banks indicate that the backwater probably was not often part of the flowing channel during spring runoff, while a predominantly cobble bank that lacked vegetation indicated that the backwater probably experienced flushing flows during spring runoff. A combination of vegetation characteristics and bank composition, intermediate between the two previous categories was used as an indication that the backwater was exposed to main channel flows intermittently.

Depth gages were installed at nine backwater sites to record changes in water level over the spawning and nursery period. Depth gage readings were recorded during April, May, and June. Because river flows reported at USGS gage stations located at

Steamboat Springs and Craig vary due to additional inputs between gage stations, an estimated flow at each backwater site was calculated. The difference in flow between the most upstream gage station and the most downstream gage station in the study area was divided by the total distance to get a flow gain/loss per mile. The distance from the most upstream gage station to each site was calculated to determine the appropriate flow per mile to add or subtract. Using this information a depth gage reading vs. flow relationship was developed for each backwater. A polynomial regression line was fit to the data and the equation of this line was used to calculate the depth of the backwater for any flow of interest.

Detailed habitat surveys were performed at the same nine backwaters where depth gages were installed. A surveyor level (CST/Berger Laser One, Watseka, IL) was used to determine the bottom contour of each backwater by measuring depths along transects perpendicular to the long axis of the backwater. Transects were spaced between 9.1 and 27.4 m depending on bank obstructions and the size of the backwater. Backwaters smaller than 101 m long had at least 6 transects and backwaters longer than 101 m had between 10 and 17 transects. Depth measurements were recorded every 0.9 to 2.7 m along the transect. Arcview spatial analyst (ESRI, Redlands, CA) was used to construct a contour map from the survey data. The regression of depth gage reading vs. flow and the contour map for each site was used to determine wetted area in each backwater during the spawning and nursery periods. During 2002 and 2003 the average flow from April 1 – 15 was used to determine the wetted area in each site for the spawning period. The peak flow recorded for 2002 and 2003 was used to determine the maximum wetted area in the backwater and possible connectivity to the main river channel.

During 2002, the four sites where spawning adults were collected in the trapnets and seven other backwaters were sampled for age-0 northern pike with a Smith-Root backpack electrofishing unit. During 2003, another site at river mile 169.1 was sampled in addition to the 11 from the previous year. An attempt was made to sample each site 3 times each year. Sampling took place during three periods; the end of June, the beginning of July, and the end of July. Dewatering associated with low flows and decreased flows over the summer precluded sampling at several sites in both 2002 and 2003. These sampling occasions are reported as catch per 10 minutes of electrofishing effort (CPUE) because each site varied by size.

Evaluation of Barriers

Barrier materials tested included the seine/trapnet used to collect spawning adult pike, a patchwork of materials including hardware cloth, poultry wire with 2.5 cm mesh, Kevlar coated net with 2.5 cm mesh, Kevlar coated net with 6.4 mm mesh, and polyvinylchloride (PVC) coated poultry wire with 2.5 cm mesh.

The barrier design used to determine the effectiveness of barriers consisted entirely of PVC coated poultry wire. This barrier extended from the top of one bank to the top of the opposite bank to deny fish access as the water rose during the spawning period. T-bar posts were spaced about every 1.5 m to support the fencing. Nylon zip ties were used to attach fencing panels to each other and to the posts. On dry ground below

the top of the bank the fencing was inserted into a trench and backfilled. In wetted areas, the bottom 30.5 cm of the fence was folded to lie flat along the bottom and 32 kg sandbags were placed on the folded fence material to hold it firmly to the substrate. Fence panel length varied as necessary to accommodate the variations in bank and channel shape. A variation to this design included placing rebar posts in front of the sandbag and through the fence underneath the sandbag to ensure that the sandbags could not move out of place.

The barrier design using the PVC coated poultry wire was used to evaluate the best time of the year to install barriers. Two barriers were installed during November 2002: one at river mile 197.8 and the other in the marshy area connected to the gravel pit pond at river mile 197. A third barrier was installed at river mile 152.5 during March 2003 before ice came off the river and backwater. At this site a channel was cleared across the backwater from which all ice was removed. Snow on the banks was removed down to the ground. Installation of the barrier then followed the same procedure used for installation of the other PVC coated poultry wire barriers.

To determine landowner acceptance of a pike barrier program, all landowners along the Yampa River between Steamboat Springs and Craig were sent a questionnaire by the Colorado Division of Wildlife and the Yampa River Basin Partnership (a Yampa River advocacy group) asking whether they would allow barriers to be placed on their property to block northern pike from spawning habitats. Property ownership information available from the Routt and Moffat County Assessor's office was used to compile the mailing list.

Results

Assessment of spawning and nursery habitat characteristics

The spring runoff in the Yampa River in 2002 was well below average, while in 2003 it was above average (Figure 2). Peak stream flow in 2003 at Steamboat Springs was the 16th highest on record, while in 2002 the peak spring flow was only 10 cfs above the record low of 1,080 cfs. Ice cover on the Yampa River broke up during February and March. Increasing flows during April allowed access to backwaters that were dry, or inundated additional vegetation in backwaters that held some water over the winter. Early runoff in May provided access to additional backwaters. Peak runoff, depending on the magnitude, had the potential to completely flood the river valley and provide fish access to fields and flood plain ponds.

During 2002, we documented the presence of spawning northern pike in early April soon after the ice on the river broke up and as water temperatures began to rise. Peak use of the backwater spawning habitat by sexually mature northern pike occurred in early April (Figure 3). Expression of gametes determined sexual maturity. Our collections of pike at this time consisted of many more males than females. By mid May very few sexually mature northern pike were collected entering or exiting the backwater habitats. During 2002, temperature loggers were installed at the same time as the trapnet/seine, and water temperatures were at or above 7.8° C in the river and in the

backwater spawning habitats during the period when we observed northern pike spawning. During 2003, water temperatures in the Yampa River near Hayden did not reach 4.4° C until late March and did not consistently reach 7.8° C until early April.

An examination of the 1999 aerial photographs of the river indicated the existence of more than 100 potential backwaters between Steamboat Springs and Craig. During our on-the-ground investigations between Steamboat Springs and Craig, only 52 possible spawning backwaters were identified. Some presumed backwaters in the 1999 photos probably no longer existed, were active side channels or dry, or were misidentified from irrigation ditches. During sampling for age-0 pike in 2002 and 2003, backwaters smaller than 557 m^2 had few fish and never more than 10 age-0 pike on a single sampling occasion. Therefore, backwaters that were smaller than this size were deemed unproductive sites for northern pike recruitment. Nineteen of the 52 sites were smaller than 557 m^2 and would be expected to contribute very few age-0 pike. Of the remaining 33 larger sites, 8 showed signs of flushing flow effects from spring runoff, 13 showed some signs of flow effects, and 12 showed no signs of flushing flow impacts (Figure 4). The 12 backwaters larger than 557 m^2 that showed no signs of flushing flow impacts from spring runoff and the 5 backwaters larger than 557 m^2 that showed some signs of flow effects and were "perpendicular" to the main channel with only one point of connection to riverine flows were considered to be the best backwater spawning habitats available.

Regressions of depth vs. flow were based on 9 to 14 data points depending on the site, which resulted in r^2 values between 0.94 and 0.99. Analysis of contour maps and depth vs. flow information for each study site revealed that wetted area showed only a small change between 2002 and 2003 during early April (April 1-15) even though the spring runoff was dramatically different in the two years (Table 1). The site at river mile 155 was the only site that showed a dramatic change in wetted area, but this site had a low floodplain separating the backwater from the river, which allowed for a large change in area from a small change in water depth. Contour maps for this site during the peak spring flow of 2002 and 2003 showed that this was the only site connected to the main channel during both years. Two sites showed possible connection and the rest did not show connection to the main channel during the peak spring runoff of 2002. During the higher peak spring runoff in 2003 one site showed no connection, one site showed possible connection and the rest were connected to the main channel during the spring runoff.

Age-0 northern pike were sampled at 11 sites during 2002 and 12 sites during 2003. The first sampling period was June 25-28, 2002 and June 24-27, 2003. The second sampling period was July 10-11, 2002 and June 30-July 2, 2003. The third sampling period was July 20-23, 2003. Five sites were dewatered before sampling began in 2002, but age-0 northern pike were found in the river adjacent to one dry site. Also during 2002, most backwaters were dry by the end of July so the third period samples were not collected. During 2003, one site was not sampled and one site dewatered during the second sampling period and two additional sites dewatered before the third sampling period. The CPUE information in 2002 shows a wide range in CPUE for backwater

habitats, with the majority of samples being low or zero and one isolated case of a larger CPUE (Figure 5). Backwater habitats in 2003 consistently had a low CPUE during all three sampling periods, while the pond habitat had a large CPUE during the first two periods and a decreased CPUE during the third period. This change in CPUE during the third period may be due to age-0 pike evading the electrofishing equipment as they grew larger. The largest total catch of age-0 pike came from the gravel pit pond outlet during 2003 when on a single sampling occasion 44 age-0 pike were found. In addition, numerous age-0 northern pike were observed around the gravel pit pond margins suggesting that this area and associated habitat was well suited for pike recruitment. Overall, no age-0 pike were collected in 18 of the 37 backwaters sampled, and 32 of the 37 backwaters sampled resulted in a CPUE of less than 3.

Evaluation of Barriers

The barrier installed at river mile 197.8 during the fall did not withstand winter ice conditions and was repaired immediately after ice-out in March of 2003. No northern pike were visually observed behind the barrier at this time. The repaired barrier appeared to function well and before it was removed on May 15, 2003, an overnight gillnet set behind the barrier failed to catch any northern pike.

Although the barrier installed in the spawning area adjacent to the gravel pit pond at river mile 197 was not damaged over the winter, the barrier did not function as expected. Water entering the back end of the area carried considerable organic debris that was deposited on the face of the barrier, creating a dam. Water pressure from the raised water level behind the barrier dislodged sandbags holding the barrier fencing to the bottom.

The barrier installed at river mile 152.5 shortly before ice-out was able to withstand the ice break up. However, it was not effective because of muskrat disruption of the barrier. We believe muskrats burrowed under the barrier, causing the sandbags to slide out of place and opening the seal between the barrier fencing and the backwater bottom. Steel rebar posts inserted in front of the sandbags and through the underlying fencing stopped the sandbags from moving out of place and no further problems were observed.

The landowner questionnaire was sent to 169 property owners along the Yampa River and 83 responses were received. Fifty-six percent of the respondents said they would allow a barrier on their property, 23% said maybe and would like more information, and 20% said no.

Discussion

Assessment of spawning and nursery habitat characteristics

During the winter, backwaters were either dry, frozen solid or had narrow unfrozen sections with low oxygen levels, probably from decaying vegetation. It is unlikely that northern pike inhabit backwaters during the winter for these reasons and

instead wait for appropriate spawning temperatures to initiate migration into these areas. The water temperatures and the presence of large numbers of adults congregating in the backwaters in early April suggest that the primary spawning period in the Yampa River occurs during this period. We continued to collect sexually mature northern pike throughout May, which was similar to the findings of Nesler (1995). These results suggest that the entire spawning period may last for about a month, as has been reported elsewhere (Farrell 2001; Miller et al. 2001). The presence of more males than females during the primary spawning period is consistent with other studies of northern pike spawning activity (Billard 1996).

The dynamic nature of lotic systems makes identifying spawning habitats challenging. For example, spawning habitat that may look suitable during April may be negatively affected by the spring runoff in May and areas that look good during May might not have water during the early April spawning period. From year to year the quality of nursery habitat can change because of different spring runoff levels. Initial counts of backwater habitats in the river indicated that they were widespread, but closer observation revealed that good spawning and nursery habitat is limited. Backwater orientation to the river was a major indicator of whether the backwater would be protected or not from spring runoff flows and thus serves as good nursery habitat. Backwaters that are parallel to the main river channel have the possibility of experiencing direct flow through the backwater if it connects to the main channel during spring runoff, thus lowering the value of these areas as nursery habitat. In contrast, backwaters that are more or less perpendicular to the main channel are less likely to receive direct flow through them during spring runoff. Large backwaters of this type were relatively uncommon in our study area.

The amount of spawning habitat available does not seem to differ greatly from year to year, regardless of the magnitude of spring runoff, but spring runoff could seriously impact the recruitment of age-0 northern pike during the nursery period. Our analysis of backwaters indicated that a large majority showed signs of being connected to the main channel during a typical spring runoff. During a runoff of large magnitude, similar to 2003, we observed that most backwater nursery habitats became part of the main channel or at least experience increased flows. During a spring runoff of low magnitude, as in 2002, backwater nursery habitat is less likely to connect to the main channel, but has the added threat of being dewatered. On these occasions some age-0 pike are able to find suitable nursery habitat in low velocity areas of the main channel, which can serve as de facto backwater habitat. While the spring runoff appears to create abundant backwater nursery habitat, these habitats may in fact be unsuitable for age-0 pike because of flushing flows.

Based on our observations, the primary spawning period on the Yampa River is from April 1-15. Egg incubation may last between 12 and 17 days at water temperatures between 7.8° and 10° C (Swift 1965) at which point larvae attach to vegetation for 5-12 days (Billard 1996) after which they become free-swimming (Figure 6). Based on this age-0 northern pike timeline for development, we suspect that spring runoff flows in May and June could be detrimental to age-0 northern pike recruitment. Most backwaters available for spawning and nursery habitat experience strong currents during spring flows

that could flush northern pike fry into the main channel. It has been well documented that age-0 pike are reliant upon vegetated nursery habitat for survival. Holland and Huston (1984) found that age-0 pike were 10 times more abundant in backwater areas with vegetation compared to areas lacking vegetation. During a normal water year the main channel of the Yampa River is devoid of calm, well vegetated areas, except for river backwaters. We would expect that successful recruitment of age-0 pike could only take place if they are able to remain in these backwaters, or able to return to these areas after being forced into the main channel. Large numbers of age-0 pike were never found in the main channel or in the backwaters, suggesting that recruitment from these Yampa River habitats is limited.

Well-managed northern pike spawning marshes are capable of producing in excess of 200 age-0 northern pike per year per 557 m^2 (Royer 1971). No riverine spawning sites we investigated came close to producing this many pike. Age-0 pike were typically mobile and visible during electrofishing collections. The majority of backwaters sampled had few age-0 pike and few were observed during sampling. Therefore, we do not believe a large number of age-0 pike were present. The specific sites we intensively sampled for age-0 pike appeared to us to be the best sites available in the entire study area. They were among the larger sites and were generally isolated from the negative impacts of spring runoff flows. The combination of small spawning areas, large water level fluctuations, and disruptive flows lead us to believe that the number of successful backwater spawning locations on the Yampa River is very limited.

Nesler (1995) reported that over a four-year period of sampling with seines and electrofishing between river mile 45.4 and 152.5 only 3 age-0 northern pike were collected, all from areas upstream of river mile 139 (Craig). Our sampling for age-0 pike in backwaters typically resulted in zero to 5 age-0 pike in an entire sampling area, with only a few occasions resulting in 10 to 25 age-0 pike in an entire backwater. Overall, the greatest numbers of age-0 pike were found at the gravel pit pond site. Based on the apparent stability of the gravel pit and other off channel ponds and their relative impunity to variations in river flows, it is not surprising that the gravel pit pond would produce the greatest number of age-0 pike. The pond site we examined was less prone to water level fluctuations than those sites more directly influenced by the Yampa River and was more similar to stable lentic environments often associated with good northern pike habitat.

While our sampling of pond habitat only included one site, we believe that the majority of successful northern pike recruitment takes place in off channel ponds. Analysis of aerial photographs showed that there are as many as 72 such ponds totaling about 158 ha along the Yampa River that are always open to the river or could be connected during spring runoff. Most of these ponds are clustered near Steamboat Springs and Craig and typically are remnants of gravel mining operations. Ponds that are connected to the river are likely sources of northern pike recruitment. The more isolated ponds could also account for a significant infusion of age-0 northern pike to the river if they are deep enough to support over winter survival of adults. In such cases, young northern pike could move into the river every few years when the spring flows are large enough to connect the pond with the river. We also found northern pike escaping from

Catamount Reservoir into the Yampa River. Catamount Reservoir is located on the Yampa River upstream of Steamboat Springs. Northern pike tagged during May 2003 as part of another study were captured in the spill basin below Catamount Dam in June of 2003. Another reservoir, Stagecoach Reservoir, located 4.8 km upstream of Catamount Reservoir, and Elkhead Reservoir located between Hayden and Craig, may also be contributing northern pike to the Yampa River. We suspect that these reservoirs and the numerous off channel ponds may actually be contributing more age-0 and adult northern pike to the Yampa River than any riverine backwater spawning habitats.

Evaluation of Barriers

Our intent was to design and evaluate a simple, low maintenance, low cost barrier that would keep northern pike from entering their spawning ground. Unfortunately, no barrier tested proved to be completely effective. Nylon seines were easy to install and conformed nicely to a variety of channel shapes, however, they were subject to damage from beavers and muskrats. Polyvinyl chloride coated poultry wire performed best of the materials tested. The larger mesh size available in this material reduced build up of debris and allowed adequate flows to pass while still thwarting beaver and muskrat damage. While this wire fabric prevented direct damage to the barrier, it did not stop the animals from burrowing under the structure and dislodging the sandbags anchoring the fencing in place. Adding rebar posts in front of the sandbags and through the fencing under the sandbags appeared to ensure the immobility of the sandbags. Installation of the wire mesh type of material was labor intensive and achieving a good seal with the bottom of the backwater was difficult.

Installation of barriers during low fall flows was easier and more convenient, but the barriers were generally not able to withstand winter ice conditions. Early spring installations got around some of the difficulties associated with ice formation, but were not without their problems, the biggest being that barriers needed to be installed before the ice melted. In our case we had to chip through ice that was 0.6-0.9 m thick in some places.

Installation of barriers during the early spring in the Yampa River would need to be done during a relatively narrow window of time before the water temperatures cue northern pike spawning, especially considering that pike may begin moving into spawning areas at very low water temperatures. In addition to difficulties with winter freezing, beavers, and muskrats, the number of possible spawning habitats that would need to be screened would make it prohibitive to install barriers in all of these sites during the spring period before spawning begins. Considering the low number of age-0 northern pike we encountered in the river backwaters, a massive barrier building program may not be logistically possible or economically feasible. While a majority of landowners indicated a willingness to allow barriers to be built on their property, about 20% were opposed to such actions. If high quality backwaters could not be blocked because landowner opposition, one would have to question the logic of blocking others.

Conclusions

- During 2002, the peak collection of adult spawning pike occurred in early April when trapnets were first installed.
- Ideal water temperatures for northern pike spawning occurred in early April during 2002 and 2003.
- At the nine backwaters surveyed there was very little change in the amount of area available for spawning during early April of 2002 and 2003.
- The largest catch per unit effort (CPUE) and the largest total number of age-0 pike were found at the gravel pit pond investigated in this study.
- Few age-0 pike were found in the backwater habitats investigated.
- The barriers installed during the winter did not adequately stay in place over the winter, presumably because of disruption from the ice and rising water levels.
- The barrier installed during the spring did not adequately stay in place because of either beaver or muskrat activity.
- The questionnaire sent to landowners along the Yampa River indicate that a majority of them are willing to cooperate with the Colorado Division of Wildlife, though some of these individuals may not necessarily have northern pike spawning or nursery habitat on their property.

Only Objective 1 was addressed in this study. The results and conclusions indicated exclusion of adult northern pike from spawning habitats using screening was not effective. Therefore, expanded application and evaluation of this approach on a reach-wide scale (Objectives 2 and 3) was not justified. Inadequate data was collected to address Objective 4, though preliminary evidence suggesting small reservoirs/ponds may be the primary production areas for age-0 northern pike.

Management Considerations

- The use of barriers on riverine sites may be largely not appropriate or feasible because of the apparent low numbers of northern pike being produced in the river, the difficulties associated with blocking adults from all possible sites, and private land access issues.
- Management resources may be better spent on reducing pike recruitment in the numerous off-channel lakes and ponds between Catamount Reservoir and Craig. This should include further investigation of ponds and reservoirs as sources for pike recruitment into the river.
- Blocking the connection of ponds and the outlet structures of reservoirs to the river with nets or screens or complete removal of access to reduce overall recruitment to the river population should be investigated.
- The role of Catamount and Stagecoach Reservoirs as sources of northern pike (and perhaps Elkhead Reservoir) will sustain the problem until some reduction in escapement is achieved.

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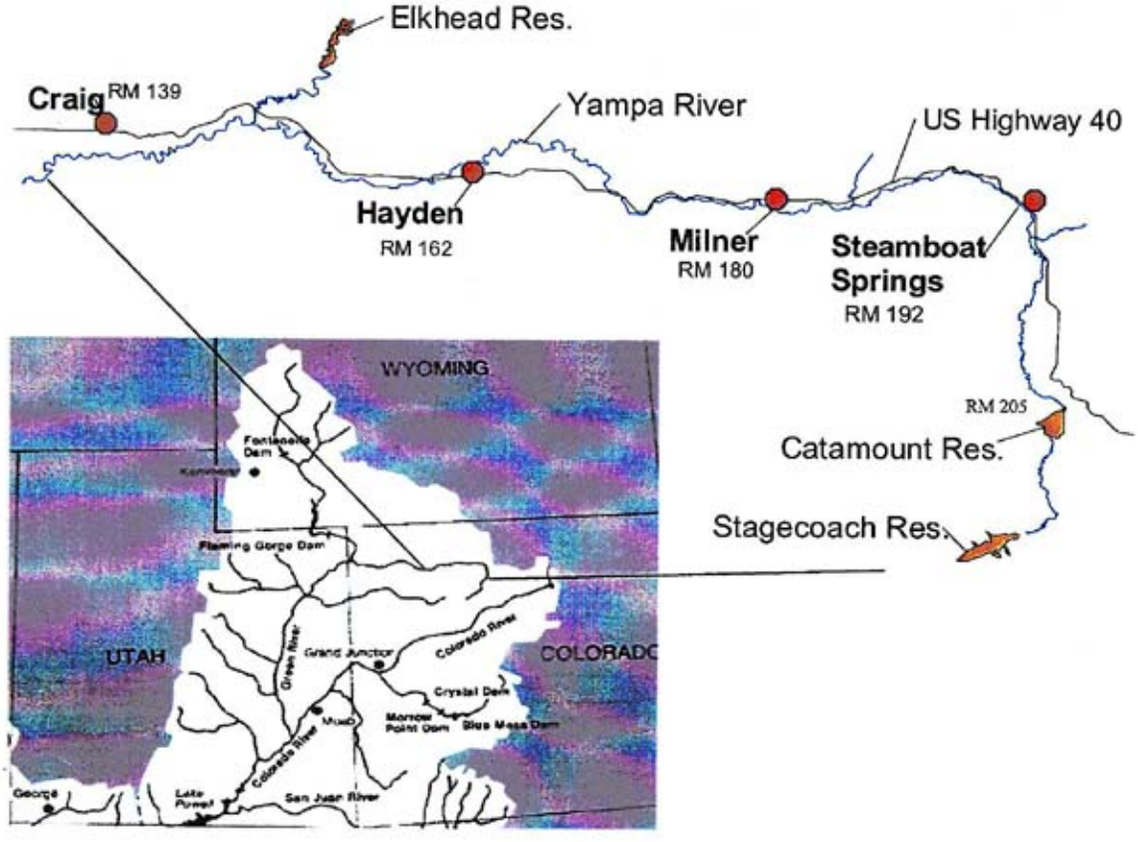


Figure 1. The study area is located in northwestern Colorado between the towns of Craig and Steamboat Springs, Colorado. The upper boundary of designated critical habitat for endangered fish in the Yampa River is at river mile (RM) 139.

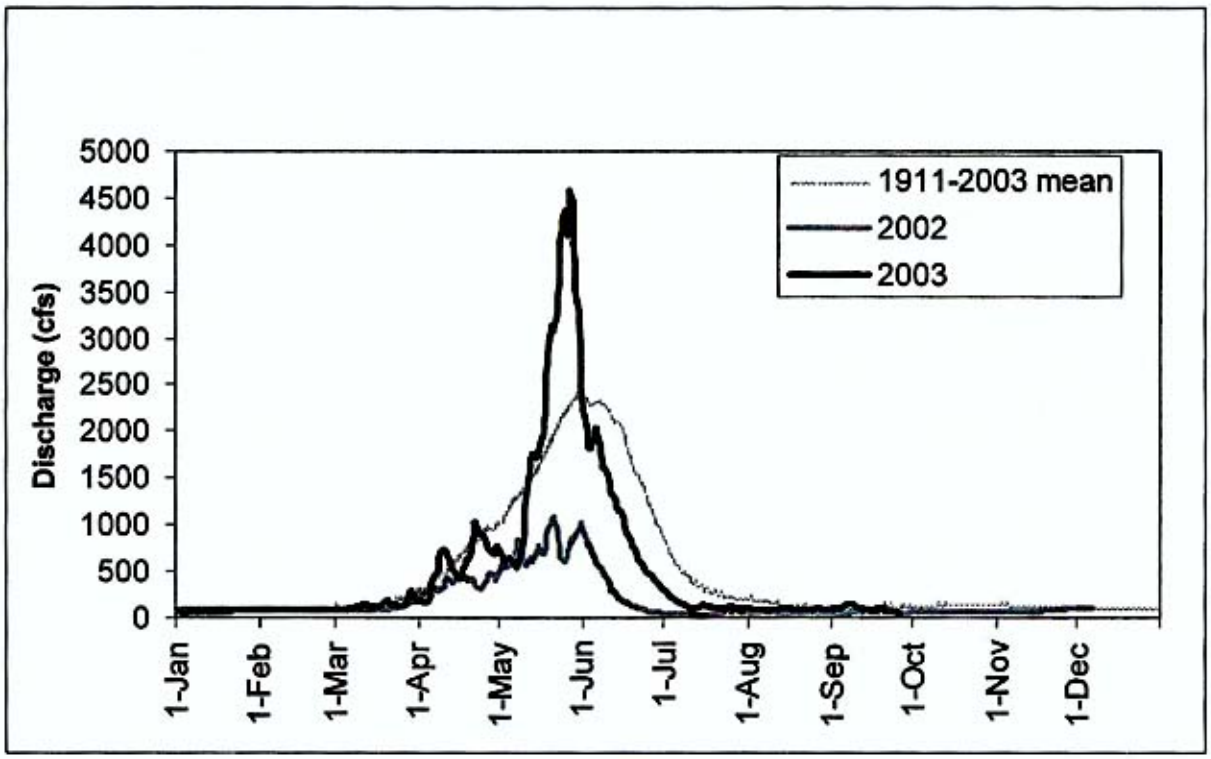


Figure 2. The mean daily discharge of the Yampa River at Steamboat Springs from 1911-2003 and during 2002 and 2003.

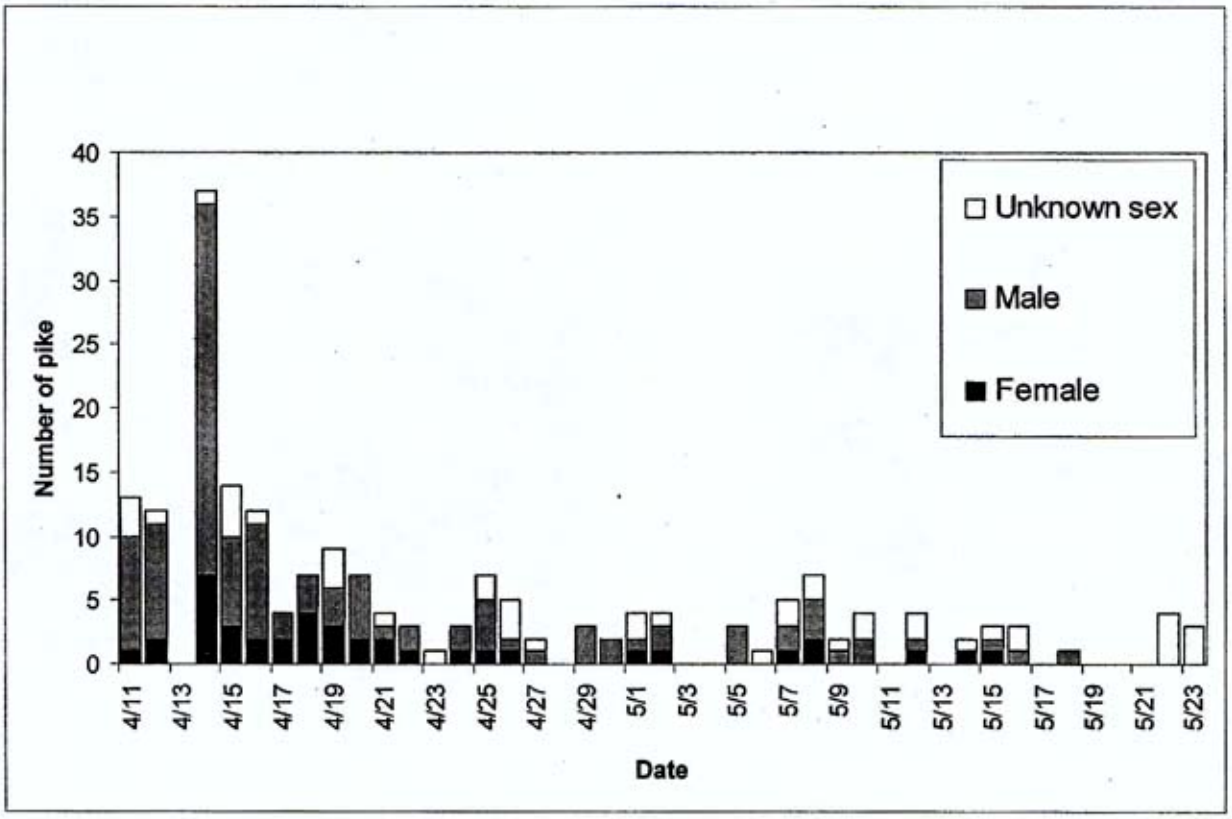


Figure 3. Adult northern pike collected in three study area backwaters between April 11, 2002 and May 23, 2002.

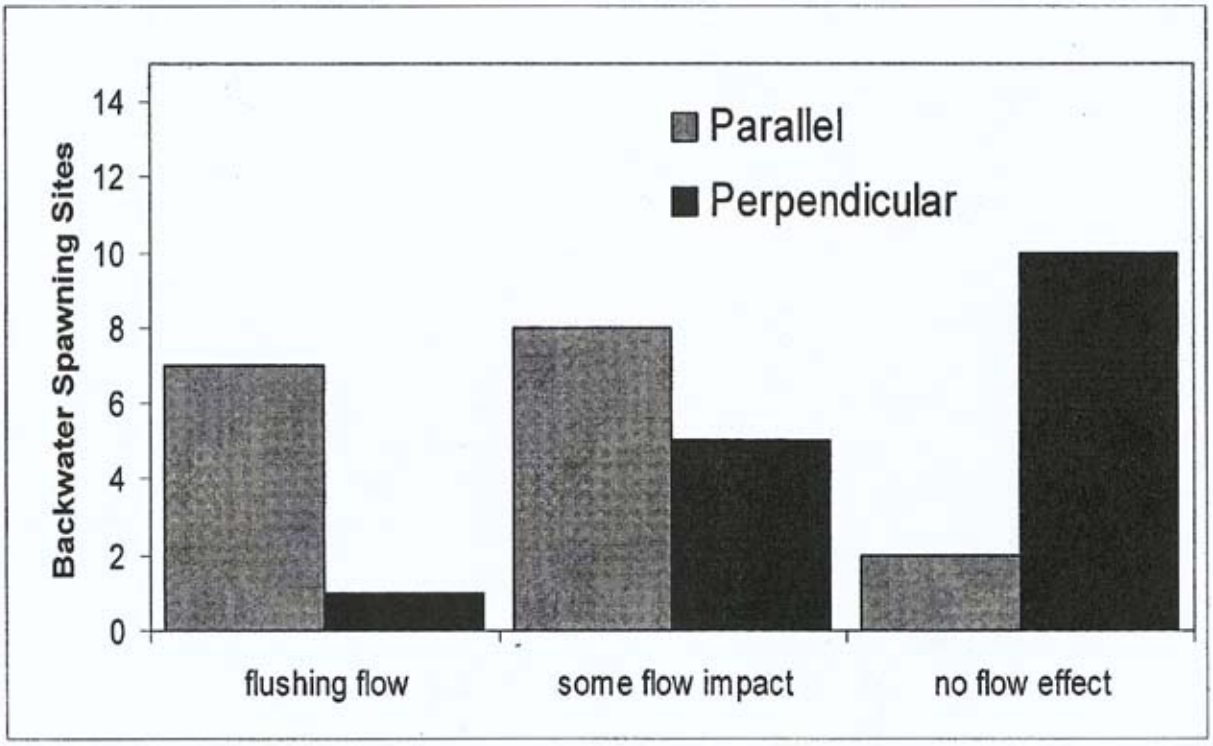


Figure 4. The number and orientation of 33 backwater sites on the Yampa River study area larger than 557 m^2. Sites were categorized by orientation to the main river channel (perpendicular or parallel) and evidence of flow effects from the main river channel during spring runoff.

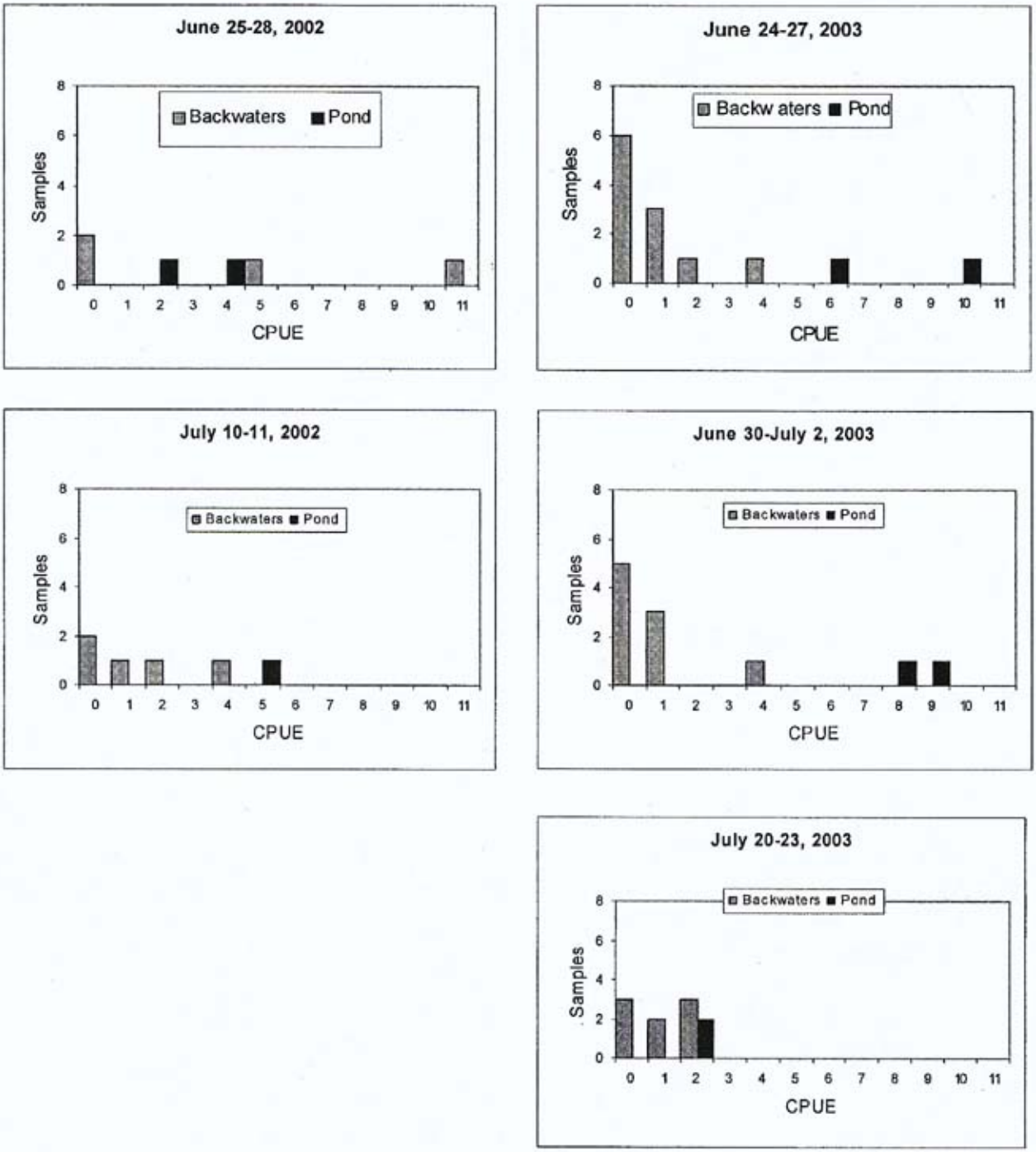


Figure 5. Frequency distribution of age-0 northern pike CPUE (age-0 northern pike collected per 10 min of electrofishing effort) in 2002 and 2003 from river backwaters and a gravel pit pond. Gravel pit pond sampling areas consisted of two sites; one where adult northern pike were collected during spawning and one where the outlet stream of the pond connected to the Yampa River. There were two sampling periods in 2002 and 3 sampling periods in 2003.

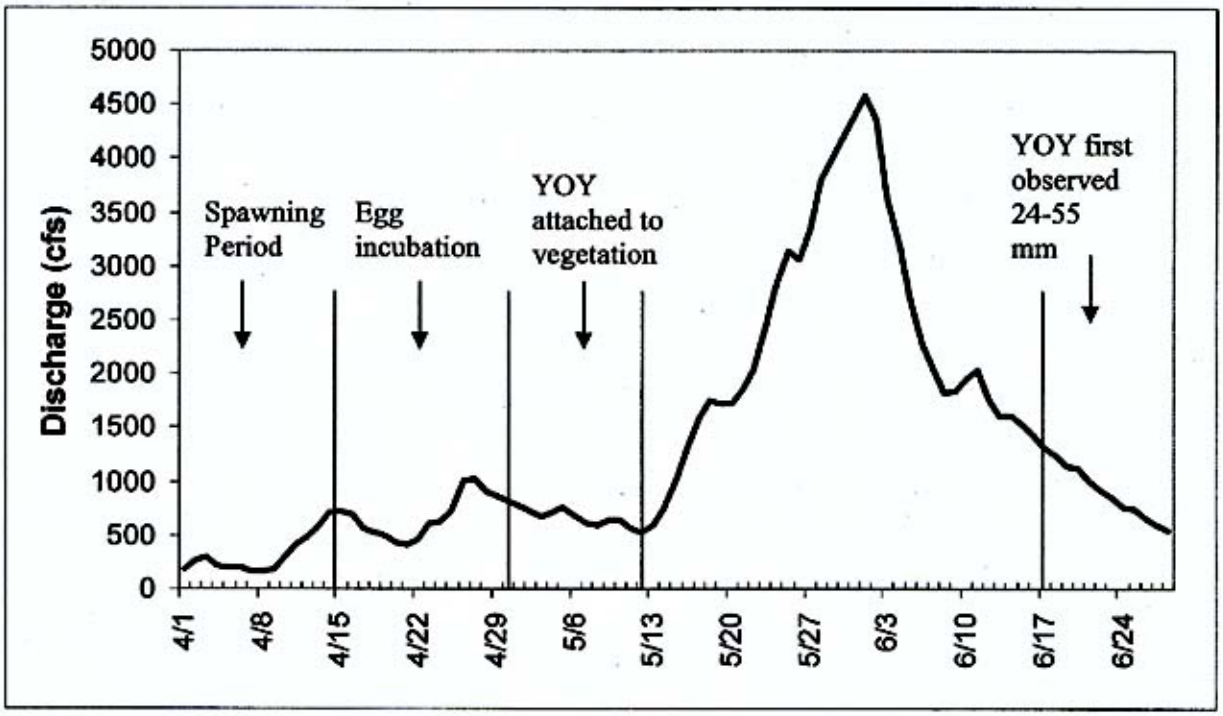


Figure 6. A timeline for likely northern pike maturation in the Yampa River and flows for April 1, 2003 to June 30, 2003. Development stages based on Swift (1965) and Billard (1996). We first observed young of the year northern pike in the river backwaters on June 17, 2003.

Site (river mile)	2002 April 1-15 Area (m^2)	2003 April 1-15 Area (m^2)	Percent Change	Exposure to flushing flows or flow effects during peak flows 2002	2003
197.8	332	333	< 1	No	No
197.8	584	584	< 1	No	Possible
174	3,370	3,639	8	No	Yes
169.1	1,080	1,135	5	Possible	Yes
163.3	1,709	1,762	3	No	Yes
155.3	229	267	16	No	Yes
155	1,386	1,878	36	Yes	Yes
154.2	192	201	4	Possible	Yes
152.5	2,630	2,946	12	No	Yes

Table 1. Wetted areas for nine selected backwaters during early April 2002 and 2003 based on computer simulation, the change in area between years, and the extent of flow effects via main channel connection during peak spring runoff in 2002 and 2003.

APPENDIX A

Northern Pike Tagging and Backwater Movement Information

Adult pike length, weight, sex, tag number, collected moving in or out of the backwater, and recapture information from northern pike collected with trapnets during the spring of 2002. Site collected is denoted by river mile. Sex of the fish was determined by the presence of eggs or milt (f = eggs, m = milt, and n = no eggs or milt). The first capture includes all fish when they were initially collected and tagged. Each recapture indicates whether a pike was recaptured moving in or out of the backwater. Three pike collected were too small to tag and are represented by an x in the tag # column. An x in the weight column indicates that a weight was not taken. Pike number 26 carried a Colorado Division of Wildlife tag # 00762 and pike number 282 had CDOW tag # 00823. It is unknown when or who tagged these fish. This section does not include information about the pike I collected below Catamount Reservoir that were tagged by another researcher.

First, Second, Third... Catch
(All fish that we caught are listed in the first catch, each additional page lists the fish that were caught two, three, four...times)

Tag #
Fish were tagged with yellow floy tags, one side listed a contact phone number and printed on the other side is CCFWRU and a three digit number between 001 and 500. Some fish were not tagged so an x is in the place of a tag #

Date
The date the pike was caught

Location (rivermile)
The rivermile where the pike was captured. Recaptured pike may have been recaptured at a new site.

Trapnet Direction
Pike were collected with trapnets. The direction indicates whether the fish was moving in or out of the backwater.

Length (mm)
The total length was measured at the initial capture and is reported in mm.

Weight (g)
Weight was originally recorded in lb and oz and converted to grams

Weight (lb, oz)
Weight measurements were not taken at the beginning of the study so not all fish have weight measurements. Weights were taken with an electronic scale that gave the weight in lb and oz.

Ripe
Each pike collected was checked for the presence of eggs or milt. m=milt, f=eggs, n=no eggs or milt present

Appendix A

First Catch

Tag #	Date	Location (rivermile)	Trapnet Direction	Length (mm)	Weight (g)	Weight (lb, oz)	Ripe
1	4/12/2002	174	in	680	x	x	m
2	4/12/2002	174	in	670	x	x	m
3	4/12/2002	174	in	740	x	x	m
4	4/12/2002	174	out	640	x	x	m
5	4/14/2002	174	in	740	x	x	f
6	4/14/2002	174	in	715	x	x	m
7	4/14/2002	174	in	640	x	x	m
8	4/14/2002	174	in	630	x	x	m
9	4/14/2002	174	out	670	x	x	m
10	4/14/2002	163.3	out	570	x	x	m
12	4/14/2002	163.3	out	580	x	x	m
13	4/14/2002	163.3	out	945	x	x	f
14	4/14/2002	163.3	out	570	x	x	m
15	4/14/2002	163.3	out	860	x	x	f
16	4/14/2002	163.3	out	640	x	x	m
17	4/14/2002	163.3	out	550	x	x	m
18	4/14/2002	163.3	out	655	x	x	m
19	4/14/2002	163.3	out	580	x	x	m
20	4/14/2002	163.3	out	575	x	x	m
21	4/14/2002	163.3	out	400	x	x	m
22	4/14/2002	163.3	out	730	x	x	m
23	4/14/2002	163.3	out	635	x	x	n
24	4/14/2002	163.3	out	565	x	x	m
25	4/14/2002	163.3	out	670	x	x	f
26	4/12/2002	174	in	650	x	x	m
27	4/19/2002	197	in	420	x	x	f
28	4/12/2002	163.85	in	300	x	x	n
29	4/19/2002	197	in	412	x	x	f
30	4/12/2002	163.85	in	575	x	x	m
31	4/12/2002	163.85	in	785	x	x	f
32	4/12/2002	163.85	in	655	x	x	m
33	4/12/2002	163.85	in	565	x	x	m
34	4/12/2002	163.85	in	670	x	x	f
35	4/11/2002	174	in	645	x	x	m
36	4/25/2002	163.3	out	576	x	x	m
37	4/11/2002	174	in	700	x	x	m
38	4/11/2002	174	in	670	x	x	m
39	4/11/2002	174	in	660	x	x	m
40	4/11/2002	174	in	645	x	x	m
41	4/11/2002	174	in	680	x	x	m
42	4/11/2002	174	in	760	x	x	n
43	4/26/2002	163.85	out	358	x	x	n
44	4/11/2002	174	in	620	x	x	m
45	4/11/2002	174	in	810	x	x	m
46	4/11/2002	174	out	460	x	x	n
47	4/25/2002	163.3	in	463	x	x	m
48	4/11/2002	174	out	670	x	x	m
49	4/11/2002	174	out	730	x	x	n
50	4/11/2002	174	out	750	x	x	f

First Catch

Tag #	Date	Location (rivermile)	Trapnet Direction	Length (mm)	Weight (g)	Weight (lb, oz)	Ripe
51	4/15/2002	174	out	730	x	x	n
52	4/15/2002	163.3	out	655	x	x	m
53	4/26/2002	163.3	in	315	x	x	n
54	4/15/2002	163.3	out	570	x	x	m
55	4/15/2002	163.3	out	565	x	x	m
56	4/15/2002	163.3	out	630	x	x	m
58	4/15/2002	163.3	out	850	x	x	f
59	4/15/2002	163.3	out	595	x	x	m
60	4/15/2002	163.3	out	710	x	x	n
61	4/15/2002	163.3	out	655	x	x	m
62	4/15/2002	163.3	in	895	x	x	f
64	4/16/2002	174	in	620	x	x	m
65	4/16/2002	174	in	395	x	x	n
66	4/16/2002	163.85	in	560	x	x	m
67	4/16/2002	163.85	in	670	x	x	m
68	4/16/2002	163.85	in	600	x	x	m
69	4/16/2002	163.3	out	670	x	x	m
69	5/18/2002	163.85	in	672	1899	4,3	m
70	4/16/2002	163.3	in	720	x	x	f
71	4/16/2002	163.3	in	565	x	x	m
72	4/16/2002	163.3	in	515	x	x	m
73	4/16/2002	163.3	in	510	x	x	m
74	4/16/2002	163.3	in	610	x	x	m
75	4/16/2002	163.3	in	866	x	x	f
76	4/17/2002	174	out	672	x	x	m
77	4/17/2002	163.85	out	552	x	x	f
78	4/17/2002	163.85	in	645	x	x	m
79	4/17/2002	163.3	in	980	x	x	f
80	4/18/2002	163.3	in	614	x	x	m
81	4/18/2002	163.3	in	752	x	x	f
82	4/18/2002	163.3	in	553	x	x	m
83	4/18/2002	163.3	in	735	x	x	f
84	4/18/2002	174	in	730	x	x	f
85	4/18/2002	174	in	618	x	x	m
86	4/18/2002	174	in	727	x	x	f
87	4/19/2002	163.3	in	780	x	x	n
88	4/19/2002	163.3	in	568	x	x	m
89	4/19/2002	163.3	in	628	x	x	n
90	4/19/2002	163.3	in	708	x	x	f
91	4/19/2002	163.3	in	813	x	x	n
92	4/19/2002	163.3	in	670	x	x	f
93	4/19/2002	163.3	out	697	x	x	m
94	4/19/2002	163.3	out	785	x	x	m
95	4/19/2002	174	in	742	x	x	f
96	4/20/2002	163.3	in	591	x	x	m
97	4/20/2002	163.3	in	613	x	x	m
98	4/20/2002	163.3	in	650	x	x	m
99	4/17/2002	197	out	309	x	x	m
100	4/17/2002	197	in	535	x	x	f

First Catch

Tag #	Date	Location (rivermile)	Trapnet Direction	Length (mm)	Weight (g)	Weight (lb, oz)	Ripe
102	4/14/2002	163.3	out	670	x	x	m
103	4/14/2002	163.3	out	460	x	x	m
104	4/14/2002	163.3	out	650	x	x	m
105	4/14/2002	163.3	out	770	x	x	f
106	4/14/2002	163.3	out	640	x	x	m
107	4/14/2002	163.3	out	575	x	x	m
108	4/14/2002	163.3	out	600	x	x	m
109	4/14/2002	163.3	out	525	x	x	m
110	4/14/2002	163.3	out	545	x	x	m
111	4/14/2002	163.3	out	655	x	x	m
112	4/14/2002	163.3	out	580	x	x	m
113	4/14/2002	163.3	out	730	x	x	f
115	4/14/2002	163.3	out	620	x	x	m
116	4/14/2002	163.3	out	535	x	x	m
117	4/14/2002	163.3	in	680	x	x	m
118	4/14/2002	163.3	in	930	x	x	f
119	4/14/2002	163.3	out	625	x	x	m
120	4/15/2002	163.85	in	335	x	x	m
121	4/15/2002	174	in	720	x	x	n
122	4/26/2002	163.3	in	337	x	x	m
123	4/15/2002	174	in	900	x	x	n
124	4/26/2002	163.3	in	270	x	x	n
125	4/15/2002	174	in	880	x	x	f
251	5/12/2002	163.3	in	603	1502	3,5	m
252	5/12/2002	197	in	510	595	1,5	n
253	5/14/2002	163.85	in	541	1021	2,4	f
254	5/14/2002	163.3	in	580	1105	2,7	n
255	5/15/2002	197	in	298	85	0,3	n
256	5/15/2002	163.3	in	654	1871	4,2	m
257	5/15/2002	163.3	in	590	1276	2,13	few eggs
258	5/15/2002	163.3	in	788	3515	7,12	f
259	5/16/2002	163.3	in	330	227	0,8	n
260	5/16/2002	163.3	in	333	198	0,7	n
261	5/16/2002	174	in	585	1304	2,14	m
262	5/19/2002	197	in	620	1105	2,7	n
263	5/19/2002	197	out	595	1077	2,6	m
264	5/23/2002	197	out	350	283	0,10	n
265	5/23/2002	163.85	in	352	255	0,9	n
266	5/22/2002	163.85	in	766	3033	6,11	n
267	5/22/2002	163.85	in	741	2155	4,12	n
276	5/12/2002	174	in	860	4704	10,6	n
277	4/20/2002	163.3	in	720	x	x	f
278	4/20/2002	163.3	in	798	x	x	f
279	4/20/2002	163.3	in	746	x	x	m
280	4/20/2002	174	out	621	x	x	m
281	4/21/2002	163.3	in	622	x	x	f
282	4/21/2002	163.3	in	694	x	x	m
283	4/21/2002	163.3	out	954	x	x	n
284	4/21/2002	174	out	696	x	x	f

First Catch

Tag #	Date	Location (rivermile)	Trapnet Direction	Length (mm)	Weight (g)	Weight (lb, oz)	Ripe
285	4/21/2002	197	out	627	x	x	m
286	4/22/2002	163.3	in	930	x	x	f
287	4/22/2002	163.85	out	423	x	x	m
288	4/22/2002	197	in	x	x	x	f
289	4/22/2002	174	in	363	x	x	m
290	4/23/2002	163.3	in	345	x	x	n
291	4/23/2002	197	out	417	x	x	few eggs
292	4/24/2002	163.3	in	645	x	x	m
293	4/24/2002	163.3	in	835	x	x	f
294	4/24/2002	163.3	in	630	x	x	m
295	4/24/2002	197	in	475	x	x	f
296	4/25/2002	174	in	408	x	x	m
297	4/25/2002	163.3	in	748	x	x	n
298	4/25/2002	163.3	in	545	x	x	m
299	4/25/2002	163.3	in	587	x	x	f
300	4/25/2002	163.3	in	726	x	x	n
301	4/26/2002	174	out	937	x	x	f
302	4/26/2002	197	in	284	x	x	m
303	4/27/2002	163.3	out	620	x	x	m
304	4/27/2002	163.3	in	490	x	x	n
305	5/8/2002	163.85	out	274	113	0,4	n
306	4/29/2002	174	out	675	x	x	m
307	4/29/2002	174	out	653	x	x	m
308	4/29/2002	197	in	524	x	x	f
309	4/29/2002	197	in	644	x	x	m
310	4/30/2002	197	in	599	x	x	n
311	4/30/2002	174	out	566	x	x	m
312	4/30/2002	163.85	out	483	x	x	m
313	5/1/2002	174	in	402	x	x	n
314	5/1/2002	174	out	697	x	x	m
315	5/1/2002	174	out	724	x	x	f
316	5/1/2002	174	out	839	x	x	n
317	5/2/2002	163.85	in	479	x	x	f
318	5/2/2002	163.85	in	475	x	x	f
319	5/2/2002	163.3	out	332	x	x	m
320	5/2/2002	163.3	in	388	x	x	m
321	5/5/2002	163.3	in	460	x	x	m
322	5/5/2002	163.85	out	555	1106	2,7	m
323	5/5/2002	174	in	705	2210	4,14	m
324	5/5/2002	197	in	615	1474	3,4	m
325	5/6/2002	163.3	in	595	1247	2,12	n
326	5/7/2002	163.85	in	488	879	1,15	f
327	5/7/2002	163.85	in	651	2013	4,7	m
328	5/7/2002	163.85	out	557	1049	2,5	n
329	5/7/2002	163.3	in	527	879	1,15	m
330	5/7/2002	163.3	in	659	1701	3,12	n
331	5/8/2002	174	in	982	6235	13,12	f
332	5/8/2002	174	in	703	1984	4,6	m
333	5/8/2002	163.85	in	649	1814	4,0	m

Appendix A

First Catch

Tag #	Date	Location (rivermile)	Trapnet Direction	Length (mm)	Weight (g)	Weight (lb, oz)	Ripe
334	5/8/2002	163.85	in	505	879	1,15	m
335	5/8/2002	163.85	in	796	3345	7,6	f
336	5/8/2002	163.3	in	733	2580	5,11	n
337	5/9/2002	163.3	in	913	6350	14,0	n
339	5/9/2002	174	in	661	1587	3,8	m
340	5/10/2002	197	in	277	113	0,4	n
341	5/10/2002	197	in	375	284	0,10	m
342	5/10/2002	163.85	out	550	1049	2,5	m
343	5/10/2002	163.85	out	503	879	1,15	m
344	5/10/2002	163.3	out	750	2665	5,14	few eggs
345	5/10/2002	163.3	in	590	1020	2,4	n
346	5/11/2002	197	in	720	1814	4,0	n
347	5/11/2002	197	out	465	539	1,3	few eggs
348	5/11/2002	197	in	314	141	0,5	n
349	5/12/2002	163.3	in	900	5500	12,2	f
350	5/12/2002	163.3	out	790	2806	6,3	n
x	5/23/2002	163.3	out	288	x	x	n
x	4/12/2002	163.85	in	290	x	x	m
x	5/23/2002	163.85	out	270	x	x	n

Second Capture

Tag #	Date	Location (rivermile)	Trapnet Direction	Length (mm)	Weight (g)	Weight (lb, oz)	Ripe
1	5/2/2002	174	out	680	x	x	m
2	4/14/2002	174	out	670	x	x	m
3	5/3/2002	174	in	740	2409	5,5	m
5	5/9/2002	caught at TNC by FWS					
6	4/29/2002	174	out	715	x	x	m
7	4/21/2002	174	out	640	x	x	m
8	4/17/2002	174	out	630	x	x	m
9	4/25/2002	caught at TNC by FWS			x	x	
17	5/7/2002	163.3	out	550	935	2,1	m
19	5/5/2002	163.3	in	580	1219	2,11	m
20	4/15/2002	163.3	in	575	x	x	m
22	4/24/2002	163.3	out	730	x	x	m
24	5/10/2002	163.3	caught and kept by angler				
26	5/2/2002	caught at TNC by FWS					
30	4/15/2002	163.85	out	575	x	x	m
31	4/15/2002	163.85	out	785	x	x	f
32	4/15/2002	163.85	out	655	x	x	m
33	4/15/2002	163.85	out	565	x	x	m
34	4/15/2002	163.85	out	670	x	x	f
35	4/12/2002	174	out	645	x	x	m
37	4/12/2002	174	out	700	x	x	m
38	4/12/2002	174	out	670	x	x	m
39	4/12/2002	174	out	660	x	x	m
40	4/12/2002	174	out	645	x	x	m
41	4/12/2002	174	out	680	x	x	m
42	4/12/2002	174	out	760	x	x	n
43	4/27/2002	163.85	in	358	x	x	n
44	4/15/2002	174	in	620	x	x	m
45	4/12/2002	174	out	810	x	x	m
46	5/16/2002	174	in	460	?	?	n
47	4/29/2002	163.85	out	463	x	x	m
48	4/15/2002	174	in	670	x	x	m
50	4/14/2002	174	in	750	x	x	f
52	5/7/2002	163.3	in	655	1672	3,11	m
59	4/16/2002	163.3	in	595	x	x	m
61	4/20/2002	163.3	in	655	x	x	m
62	4/16/2002	163.3	out	895	x	x	f
64	4/17/2002	174	out	620	x	x	m
66	4/17/2002	163.85	in	560	x	x	m
67	4/20/2002	163.85	out	670	x	x	m
68	4/21/2002	163.85	out	600	x	x	m
70	4/17/2002	163.3	out	720	x	x	f
74	4/18/2002	163.3	in	610	x	x	m
77	4/19/2002	163.85	out	552	x	x	f
78	4/19/2002	163.85	out	645	x	x	m
81	4/19/2002	163.3	out	752	x	x	f
82	4/19/2002	163.3	out	553	x	x	m
83	4/19/2002	163.3	out	735	x	x	f
85	5/13/2002	caught at TNC by FWS					

Second Capture

Tag #	Date	Location (rivermile)	Trapnet Direction	Length (mm)	Weight (g)	Weight (lb, oz)	Ripe
86	4/19/2002	174	out	727	x	x	f
87	4/27/2002	163.3	out	780	x	x	f
89	5/1/2002	163.3	out	628	x	x	n
90	5/10/2002	163.3	caught and kept by angler				
91	4/20/2002	163.3	out	813	x	x	n
92	4/20/2002	163.3	out	670	x	x	f
94	4/21/2002	163.3	in	785	x	x	n
95	4/20/2002	174	out	742	x	x	f
96	4/26/2002	163.3	out	591	x	x	m
97	4/22/2002	163.3	out	613	x	x	m
98	4/22/2002	163.3	out	650	x	x	m
100	4/20/2002	197	out	535	x	x	f
102	4/15/2002	163.3	out	670	x	x	m
104	4/17/2002	163.3	in	650	x	x	m
106	4/19/2002	163.3	out	640	x	x	m
107	5/8/2002	163.3	in	575	1049	2,5	m
109	4/25/2002	163.3	in	525	x	x	n
115	4/17/2002	163.3	in	620	x	x	m
116	4/21/2002	163.3	out	535	x	x	m
119	5/2/2002	163.3	found dead in slough,covered with algae				
121	4/15/2002	174	out	720	x	x	n
123	4/16/2002	174	out	900	x	x	n
251	5/18/2002	163.3	out	603	1446	3,3	m
253	5/15/2002	163.85	out	541	964	2,2	f
256	5/16/2002	163.3	out	654	1502	3,5	m
258	5/23/2002	163.3	out	788	2948	6,8	n
266	5/23/2002	163.85	out	766	3147	6,15	n
267	5/23/2002	163.85	out	741	2325	5,2	n
276	5/13/2002	174	out	860	4846	10,11	n
277	4/21/2002	163.3	out	720	x	x	f
278	4/22/2002	163.3	out	798	x	x	n
280	5/1/2002	174	out	621	x	x	m
282	4/22/2002	163.3	out	694	x	x	m
285	4/28/2002	197	out	627	x	x	m
286	4/22/2002	163.3	out	930	x	x	f
293	4/26/2002	163.3	out	835	x	x	n
294	4/26/2002	163.3	out	630	x	x	m
296	4/27/2002	174	out	408	x	x	m
297	4/29/2002	163.3	out	748	x	x	n
298	4/27/2002	163.3	out	545	x	x	m
299	5/18/2002	163.3	out	587	1247	2,12	n
301	5/23/2002	174	out	937	4563	10,1	n
302	5/3/2002	197	out	284	113	0,4	n
305	5/13/2002	163.85	found dead				
307	5/2/2002	174	in	653	x	x	m
311	5/7/2002	174	in	566	1247	2,12	m
312	5/2/2002	163.85	in	483	x	x	m
316	5/4/2002	174	in	839	4279	9,7	f
318	5/4/2002	163.85	out	475	737	1,10	f

Appendix A

Second Capture

Tag #	Date	Location (rivermile)	Trapnet Direction	Length (mm)	Weight (g)	Weight (lb, oz)	Ripe
320	5/13/2002	163.3	in	388	340	0,12	m
322	5/6/2002	163.85	in	555	1106	2,7	m
323	5/6/2002	174	out	705	2182	4,13	m
324	5/8/2002	197	in	615	1446	3,3	m
326	5/12/2002	163.85	out	488	709	1,9	few eggs
327	5/10/2002	163.85	out	651	1899	4,3	m
330	5/8/2002	163.3	out	659	1587	3,8	n
331	5/13/2002	174	out	982	6121	13,8	few eggs
332	5/11/2002	174	out	703	2040	4,8	m
333	5/12/2002	163.85	out	649	1758	3,14	m
334	5/22/2002	163.85	in	505	652	1,7	m
335	5/10/2002	163.85	out	796	2863	6,5	f
342	5/16/2002	163.85	in	550	1021	2,4	m
343	5/19/2002	163.85	in	503	794	1,12	m
346	5/13/2002	197	out	720	1701	3,12	n

Third Capture

Tag #	Date	Location (rivermile)	Trapnet Direction	Length (mm)	Weight (g)	Weight (lb, oz)	Ripe
1	5/11/2002	174	out	680	2153	4,12	m
2	5/8/2002	174	in	670	1984	4,6	m
3	5/8/2002	174	in	740	2408	5,5	m
6	5/1/2002	174	out	715	x	x	m
8	5/13/2002	caught at TNC by FWS					
20	5/23/2002	163.3	out	575	1020	2,4	m
22	4/25/2002	163.3	in	730	x	x	m
30	4/24/2002	163.85	out	575	x	x	m
31	4/15/02 pm	163.85	out	785	x	x	f
32	4/15/02 pm	163.85	out	655	x	x	m
33	4/22/2002	163.85	out	565	x	x	m
34	4/16/2002	163.85	out	670	x	x	f
37	5/6/2002	174	in	700	2295	5,1	m
38	5/2/2002	174	in	670	x	x	m
40	4/20/2002	174	out	645	x	x	m
41	5/6/2002	174	in	680	2012	4,7	m
42	5/3/2002	174	out	760	3004	6,10	n
47	4/30/2002	163.85	in	463	x	x	m
48	4/17/2002	174	out	670	x	x	m
50	4/17/2002	174	out	750	x	x	f
52	5/10/2002	163.3	out	655	1616	3,9	m
64	4/29/2002	174	out	620	x	x	m
66	4/20/2002	163.85	out	560	x	x	m
67	5/2/2002	163.85	in	670	x	x	n
68	4/26/2002	163.85	out	600	x	x	m
74	4/19/2002	163.3	out	610	x	x	m
77	4/20/2002	163.85	in	552	x	x	f
78	4/21/2002	163.85	in	645	x	x	m
82	4/26/2002	163.3	caught at TNC by FWS				
94	5/23/2002	163.3	out	785	3033	6,11	m
95	4/25/2002	caught at TNC by FWS					
96	5/10/2002	163.3	caught and kept by angler				
97	5/9/2002	163.3	dead, tangled in seine				
98	4/27/2002	163.3	in	650	x	x	m
102	5/10/2002	163.3	out	670	1843	4,1	n
104	4/18/2002	163.3	out	650	x	x	m
107	5/14/2002	163.3	out	575	1105	2,7	m
109	6/21/2002	caught by angler					
121	5/6/2002	174	in	720	2636	5,13	few eggs
253	5/16/2002	163.85	in	541	964	2,2	f
256	5/17/2002	163.3	in	654	1814	4,0	m
280	6/3/2002	caught at TNC by FWS					
293	5/22/2002	163.85	in	835	2977	6,9	n
297	5/22/2002	163.85	in	748	2353	5,3	n
312	5/10/2002	163.85	out	483	624	1,6	m
316	5/5/2002	174	out	839	4052	8,15	f
326	5/13/2002	163.85	in	488	709	1,9	n

Fourth Capture

Tag #	Date	Location (rivermile)	Trapnet Direction	Length (mm)	Weight (g)	Weight (lb, oz)	Ripe
30	4/27/2002	163.85	in	575	x	x	m
32	4/16/2002	163.85	in	655	x	x	m
33	4/30/2002	163.85	in	565	x	x	m
34	5/3/2002	163.85	out	670	1616	3,9	n
38	5/3/2002	174	out	670	2040	4,8	m
40	5/5/2002	174	in	645	1785	3,15	m
41	5/7/2002	174	out	680	2040	4,8	m
42	5/16/2002	174	in	760	2976	6,9	n
48	5/4/2002	174	in	670	1842	4,1	m
64	5/3/2002	174	in	620	1615	3,9	m
66	5/12/2002	163.85	out	560	1049	2,5	m
67	5/11/2002	163.85	out	670	1786	3,15	n
68	5/22/2002	163.85	out	600	1304	2,14	m
77	4/22/2002	163.85	out	552	x	x	f
78	5/15/2002	163.85	out	645	1588	3,8	m
104	5/15/2002	163.3	in	650	1956	4,5	m
121	5/9/2002	174	out	720	2636	5,13	f
312	5/13/2002	163.85	in	483	595	1,5	m

Appendix A

Fifth Catch

Tag #	Date	Location (rivermile)	Trapnet Direction	Length (mm)	Weight (g)	Weight (lb, oz)	Ripe
30	5/9/2002	163.85	out	575	1077	2,6	m
32	4/19/2002	163.85	out	655		x	m
33	5/12/2002	163.85	out	565	1247	2,12	n
34	5/4/2002	163.85	in	670	1644	3,10	n
48	5/11/2002	174	out	670	1899	4,3	m
64	5/8/2002	174	in	620	1502	3,5	m
66	5/13/2002	163.85	in	560	1021	2,4	m
67	5/18/2002	163.85	out	670	1871	4,2	n
68	5/23/2002	163.85	in	600	1278	2,13	m

Sixth Catch

Tag #	Date	Location (rivermile)	Trapnet Direction	Length (mm)	Weight (g)	Weight (lb, oz)	Ripe
30	5/10/2002	163.85	in	575	1049	2,5	m
32	5/2/2002	163.85	in	655	x	x	m
33	5/14/2002	163.85	in	565	1219	2,11	n
48	5/16/2002	174	in	670	1814	4,0	m
64	5/14/2002	174	out	620	1502	3,5	m

APPENDIX B:

Northern Pike Movement in the Yampa River

A limited number of northern pike tagged in 2002 were recaptured by other workers in 2002 and 2003. The US Fish and Wildlife service collected pike between Hayden and Craig, Colorado with trapnets in 2002 and with trapnets and electrofishing equipment in 2003. The Colorado State University Larval Fish Lab collected pike with electrofishing equipment below Craig, Colorado. This section does not include information about the pike I collected below Catamount Reservoir that were tagged by another researcher.

2002 Recaptures

FWS trapnets 02

Tag #	Tag Date	Recap date	Tag Location	Recap Location
9	4/14/2002	4/25/2002	174	169.1
95	4/19/2002	4/25/2002	174	169.1
82	4/18/2002	4/26/2002	163.3	169.1
26	4/12/2002	5/2/2002	174	169.1
5	4/14/2002	5/9/2002	174	169.1
85	4/18/2002	5/13/2002	174	169.1
8	4/14/2002	5/13/2002	174	169.1
280	4/20/2002	6/3/2002	174	169.1
5	4/14/2002	6/4/2002	174	152.5

Larval Fish Lab collections 02

Tag #	Tag Date	Recap date	Tag Location	Recap Location
31	4/12/2002	4/15/2002	163.8	Juniper Hot Springs

2003 Recaptures

This is a combination of collection information from the FWS and the original information collected when the fish was tagged, in some cases it appears that the fish collected was not a fish that I tagged.
Mark Fuller of the Fish and Wildlife Service in Vernal, Utah provided the recapture information.

Tag #	Tag Date	Recap date	Tagged Sex	Recap Sex	Tagged TL	Recap TL
49	4/11/2002	5/19/2003	u	U	730	778
339	5/9/2002	5/19/2003	m	U	661	680
112	4/14/2002	5/19/2003	m	U	580	644
268	4/10/2003	5/20/2003	f	F	610	615
333	5/8/2002	6/11/2003	m	U	649	665
18	4/14/2002	6/12/2003	m	U	655	525
1555		6/17/2003		U		955
69	4/16/2002	6/17/2003	m	U	670	719
9	4/14/2002	6/19/2003	m	U	670	696
344	5/10/2002	6/20/2003	f	U	750	780
25	4/14/2002	7/1/2003	f	U	670	724

Tag #	Tag Location (river mile)
49	174
339	174
112	163.3
268	176
333	163.8
18	163.3/not my fish or mismeasured
1555	not my tag
69	163.3
9	174, recaptured at 169.1 on 4/25/02
344	163.3
25	163.3

Tag #	Recap Area (river mile)
49	Pump Station(rm 171) to Hayden Town Bridge(rm 159)
339	Pump Station(rm 171) to Hayden Town Bridge(rm 159)
112	Pump Station(rm 171) to Hayden Town Bridge(rm 159)
268	Hayden Town Bridge (rm 159) to State Wildlife Area (151)
333	Hayden Town Bridge (rm 159) to State Wildlife Area (151)
18	State Wildlife Area (151) to Yampa Valley Golf Course (140)
1555	Pump Station(rm 171) to Hayden Town Bridge(rm 159)
69	Pump Station(rm 171) to Hayden Town Bridge(rm 159)
9	State Wildlife Area (151) to Yampa Valley Golf Course (140)
344	Pump Station(rm 171) to Hayden Town Bridge(rm 159)
25	State Wildlife Area (151) to Yampa Valley Golf Course (140)

APPENDIX C:

Age-0 Pike Collections

Age-0 northern pike were collected with a backpack electrofishing unit and some observational counts were performed on occasions when pike were able to evade the electrofishing equipment. Location of the collection is given in river miles and a brief description of the site follows. The date of collection, method of collection, number of young of the year pike encountered and time spent collecting or observing is given.

Appendix C

Young of year

Northern pike were collected with a Smith-Root backpack electrofishing unit. Only 1 pass was made through the entire backwater area because sampling muddied the water and water clarity would not return in a reasonable amount of time to make a second pass. We attempted to sample each backwater 3 times through the summer, but many backwaters were dry before sampling began in 2002 and during both years some backwaters went dry before 3 samples could be collected.

Site (river mile)
The location of collection is given in rivermiles.

Date
The date of the collection. On some occasions the backwater went dry before we began sampling or in between sampling occassions.

Method
Pike were collected with an electrofishing unit or when they could not be collected with an electrofishing unit they were visually observed and counted.

Number
The number of pike counted by observation or collected by electrofishing.

Time (sec)
The time was based on the electrofishing unit clock. On some occasions we collected a few fish while shocking and also observed some evading us while shocking. In these cases we report the number of observed evading us during the time we spent electrofishing.

Notes
This describes the site, whether it is public or private property and other information

Appendix C

2002

Site (river mile)	Date	Method	Number	Time (sec)
197.8 A	6/4/2002	obs	0	no time recorded
	dry			

Site (river mile)	Date	Method	Number	Time (sec)
197.8 B	6/26/2002	shock	13	1540
	7/11/2002	shock	6	907
	7/23/2002	shock	2	789
	7/23/2002	obs	6	obs. while shocking

Site (river mile)	Date	Method	Number	Time (sec)
197	6/13/2002	shock	11	941
	6/28/2002	shock	5	806
	7/11/2002	shock	3	364
	7/11/2002	obs	1	431 while shocking

Site (river mile)	Date	Method	Number	Time (sec)
196.5	6/12/2002	obs	17	no time recorded
	6/28/2002	shock	3	901

Site (river mile)	Date	Method	Number	Time (sec)
174	6/13/2002	shock	1	941
	6/13/2002	obs	1	obs. while shocking
	6/25/2002	shock	0	1915
	7/10/2003	shock	0	498
	7/10/2002	obs	3	obs. while shocking

Site (river mile)	Date	Method	Number	Time (sec)
169.1	did not sample in 2002			

Site (river mile)	Date	Method	Number	Time (sec)
163.85	6/13/2003	obs	0	no time recorded
	6/25/2002	shock	0	1191
	7/10/2002	shock	1	1153

Site (river mile)	Date	Method	Number	Time (sec)
163.3	6/13/2002	obs	6	no time recorded
	6/25/2002	shock	25	1316
	7/10/2002	obs	1	575 while shocking

Site (river mile)	Date	Method	Number	Time (sec)
163.3	6/25/2002	shock	3	1060
	7/10/2002	shock	3	897
	7/10/2002	obs	2	obs. while shocking

Site (river mile)	Date	Method	Number	Time (sec)
155.35	dry			

Appendix C

Site (river mile)	Date	Method	Number	Time (sec)
155	dry			
155	6/26/2002	shock	4	1414
	6/26/2002	obs	5	obs. while shocking
	7/11/2002	obs	17 or less	653 while shocking

Site (river mile)	Date	Method	Number	Time (sec)
154.45	dry			

Site (river mile)	Date	Method	Number	Time (sec)
154.2	dry			

Site (river mile)	Date	Method	Number	Time (sec)
152.5	6/27/2002	obs	15-20	no time recorded
	7/11/2002	shock	1	304
	dry			

Site (river mile)	Notes
197.8 A	Public Property- Chuck Lewis State Wildlife Area, two backwaters sampled at this site marshy area that is perpendicular to the main channel

Site (river mile)	Notes
197.8 B	Public Property- Chuck Lewis State Wildlife Area, two backwaters sampled at this site backwater is parallel to the main channel and protected from main channel by gravel bar

Site (river mile)	Notes
197	Private Property- gravel pit pond (shallow marshy area connected to pond sampled)

Site (river mile)	Notes
196.5	Private Property- outlet to the Yampa River of gravel pit pond

Site (river mile)	Notes
174	Private Property-backwater

Site (river mile)	Notes
169.1	Private Property-backwater

Site (river mile)	Notes
163.85	Private Property-backwater

Site (river mile)	Notes
163.3	Private Property-backwater

Site (river mile)	Notes
163.3	Private Property-low river levels allowed limited sampling of the river banks near the backwater

Site (river mile)	Notes
155.35	Private Property-backwater

Site (river mile)	Notes
155	Private Property-backwater
155	Private Property-low river levels allowed limited sampling of the river banks near the backwater

Site (river mile)	Notes
154.45	Private Property-backwater

Site (river mile)	Notes
154.2	Private Property-backwater

Site (river mile)	Notes
152.5	Private Property-backwater

Appendix C

2003

Site (river mile)	Date	Method	Number	Time (sec)
197.8 A	6/10/2003	shock	0	781
	6/18/2003	shock	8	1222
	6/26/2003	shock	2	551
Site (river mile)	**Date**	**Method**	**Number**	**Time (sec)**
197.8 B	6/10/2003	shock	0	614
	6/18/2003	shock	13	1776
	6/26/2003	shock	12	1804
	7/23/2003	shock	4	980
	7/23/2003	obs	14	obs. while shocking
Site (river mile)	**Date**	**Method**	**Number**	**Time (sec)**
197	6/10/2003	shock	6	511
	6/24/2003	shock	12	1241
	6/30/2003	shock	13	871
	7/23/2003	shock	2	543
Site (river mile)	**Date**	**Method**	**Number**	**Time (sec)**
196.5	6/24/2003	shock	44	2544
	6/30/2003	shock	28	2114
	7/23/2003	shock	5	1402
	7/23/2003	obs	7	obs. while shocking
Site (river mile)	**Date**	**Method**	**Number**	**Time (sec)**
174	6/24/2003	shock	2	1832
	7/2/2003	shock	1	1688
	7/23/2003	shock	0	1126
	7/23/2003	obs	1	obs. while shocking
Site (river mile)	**Date**	**Method**	**Number**	**Time (sec)**
169.1	6/24/2003	shock	0	676
	6/27/2003	shock	1	1165
	6/30/2003	shock	0	1597
	7/21/2003	shock	0	1299
Site (river mile)	**Date**	**Method**	**Number**	**Time (sec)**
163.85	6/26/2003	shock	0	1471
	7/2/2003	shock	1	1434
	7/22/2003	shock	0	1060
Site (river mile)	**Date**	**Method**	**Number**	**Time (sec)**
163.3	6/26/2003	shock	0	1128
	7/2/2003	shock	2	1051
	7/21/2003	shock	5	1506

Site (river mile)	Date	Method	Number	Time (sec)
155.35	6/25/2003	shock	2	1175
	7/1/2003	shock	0	925
	7/20/2003	shock	1	792

Site (river mile)	Date	Method	Number	Time (sec)
155	6/25/2003	shock	0	1219
	7/1/2003	shock	2	1504
	7/20/2003	shock	2	1214

Site (river mile)	Date	Method	Number	Time (sec)
154.45	6/25/2003	shock	0	539
	7/1/2003	shock	3	495
	dry			

Site (river mile)	Date	Method	Number	Time (sec)
154.2	6/25/2003	shock	0	589
	7/1/2003	shock	0	434
	dry			

Site (river mile)	Date	Method	Number	Time (sec)
152.5	6/25/2003	shock	1	1576
	7/1/2003	shock	4	1659
	7/23/2003	shock	4	1079
	7/23/2003	obs	4	obs. while shocking

Site (river mile)	Notes
197.8 A	Public Property- Chuck Lewis State Wildlife Area, two backwaters sampled at this site marshy area that is perpendicular to the main channel

Site (river mile)	Notes
197.8 B	Public Property- Chuck Lewis State Wildlife Area, two backwaters sampled at this site backwater is parallel to the main channel and protected from main channel by gravel bar

Site (river mile)	Notes
197	Private Property- gravel pit pond (shallow marshy area connected to pond sampled)

Site (river mile)	Notes
196.5	Private Property- outlet to the Yampa River of gravel pit pond

Site (river mile)	Notes
174	Private Property-backwater

Site (river mile)	Notes
169.1	Private Property-backwater

Site (river mile)	Notes
163.85	Private Property-backwater

Site (river mile)	Notes
163.3	Private Property-backwater

Site (river mile)	Notes
155.35	Private Property-backwater

Site (river mile)	Notes
155	Private Property-backwater

Site (river mile)	Notes
154.45	Private Property-backwater

Site (river mile)	Notes
154.2	Private Property-backwater

Site (river mile)	Notes
152.5	Private Property-backwater

APPENDIX D:

Summary of Off-channel Ponds

Appendix D: Off-channel ponds were identified and measured on digitized aerial photographs viewed in ESRI Arcview 3.3. The total area was determined from outlining the perimeter of the pond and Arcview 3.3 calculated the surface area.

Location	Number of Ponds	Area (ha)
Steamboat	18	56
Steamboat to Milner	15	11.3
Hayden	7	9.7
Craig	32	81
Total	**72**	**158**

APPENDIX E:

Landowner Questionnaire Response

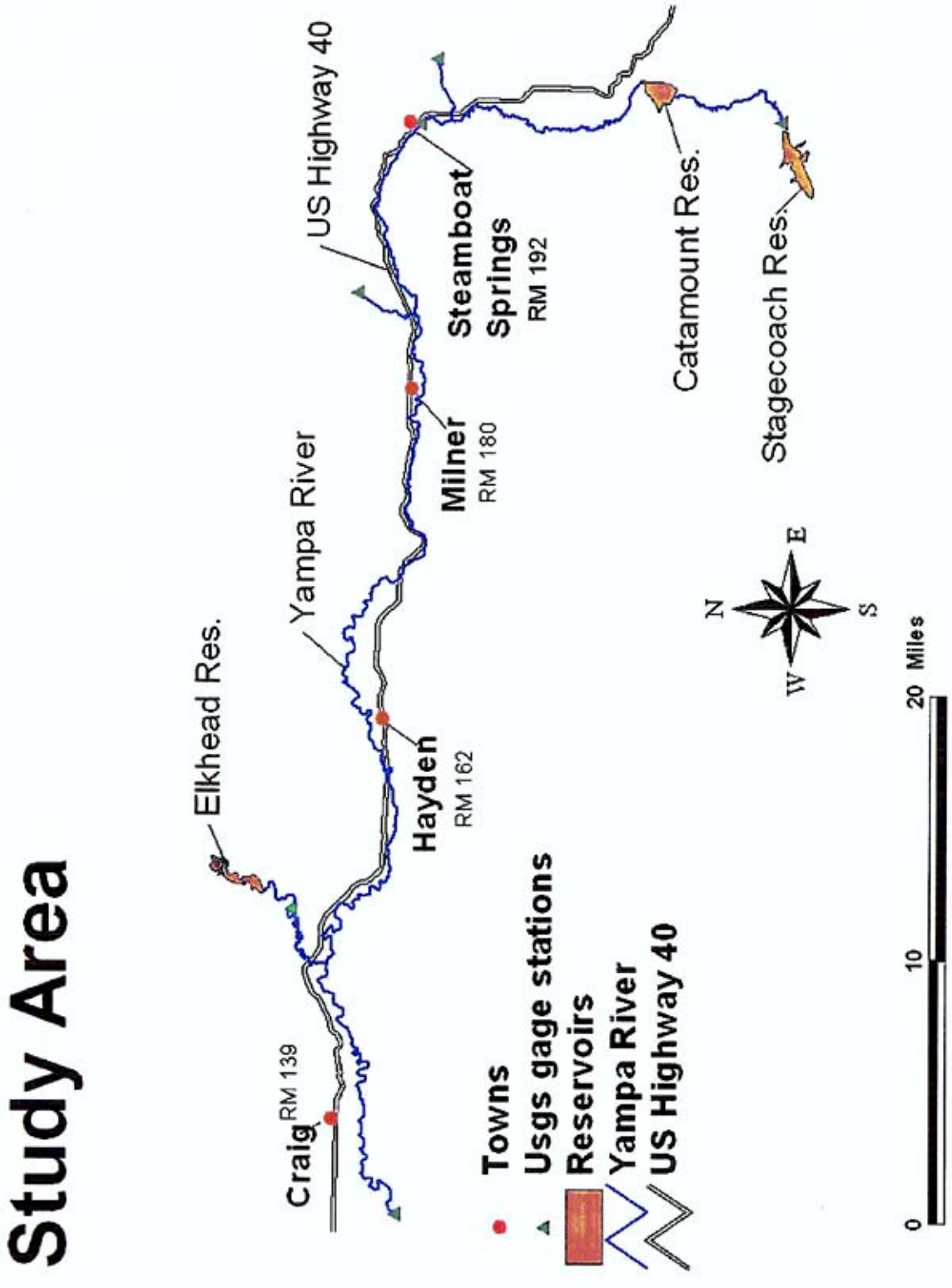
Appendix E: A questionnaire was sent to landowners whose property touches the Yampa River to determine whether they would allow barriers on their property to keep pike out of spawning habitat. The property ownership information is available from the Routt and Moffat county assessors office as GIS shapefiles, so the location of backwaters or other items of interest can be combined with the property ownership information. The response from all landowners surveyed is displayed as well as the response from landowners who had what we deemed the 17 best backwaters on their property. One of the 17 best backwaters was in Moffat County. We currently do not have the property ownership information as a GIS shapefile so we could not determine the landowners response.

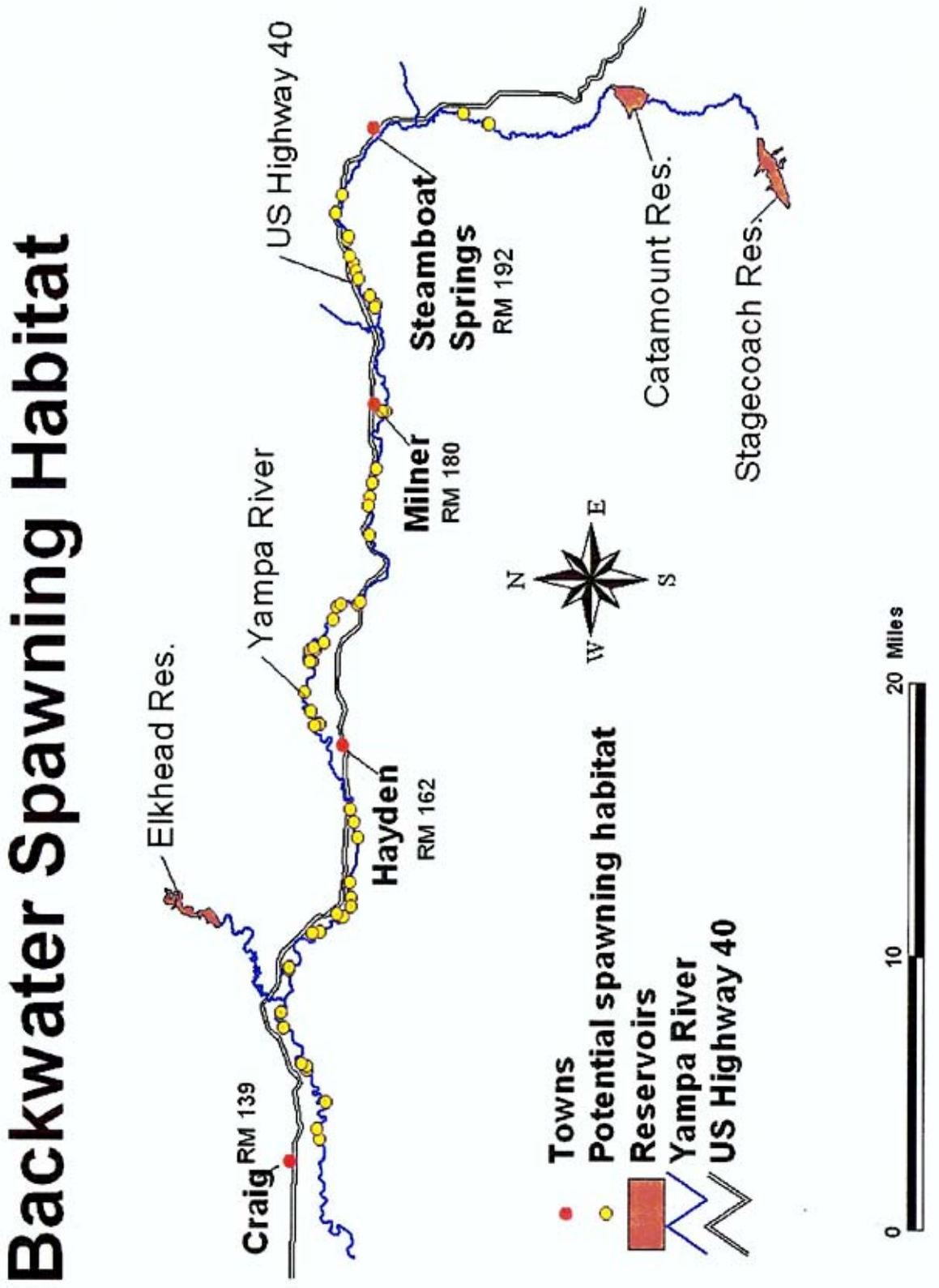
Survey Response	All Responses	Response for 17 Best Backwaters
Yes	58	5
Maybe	33	3
No	20	2
No Response	87	6

APPENDIX F:

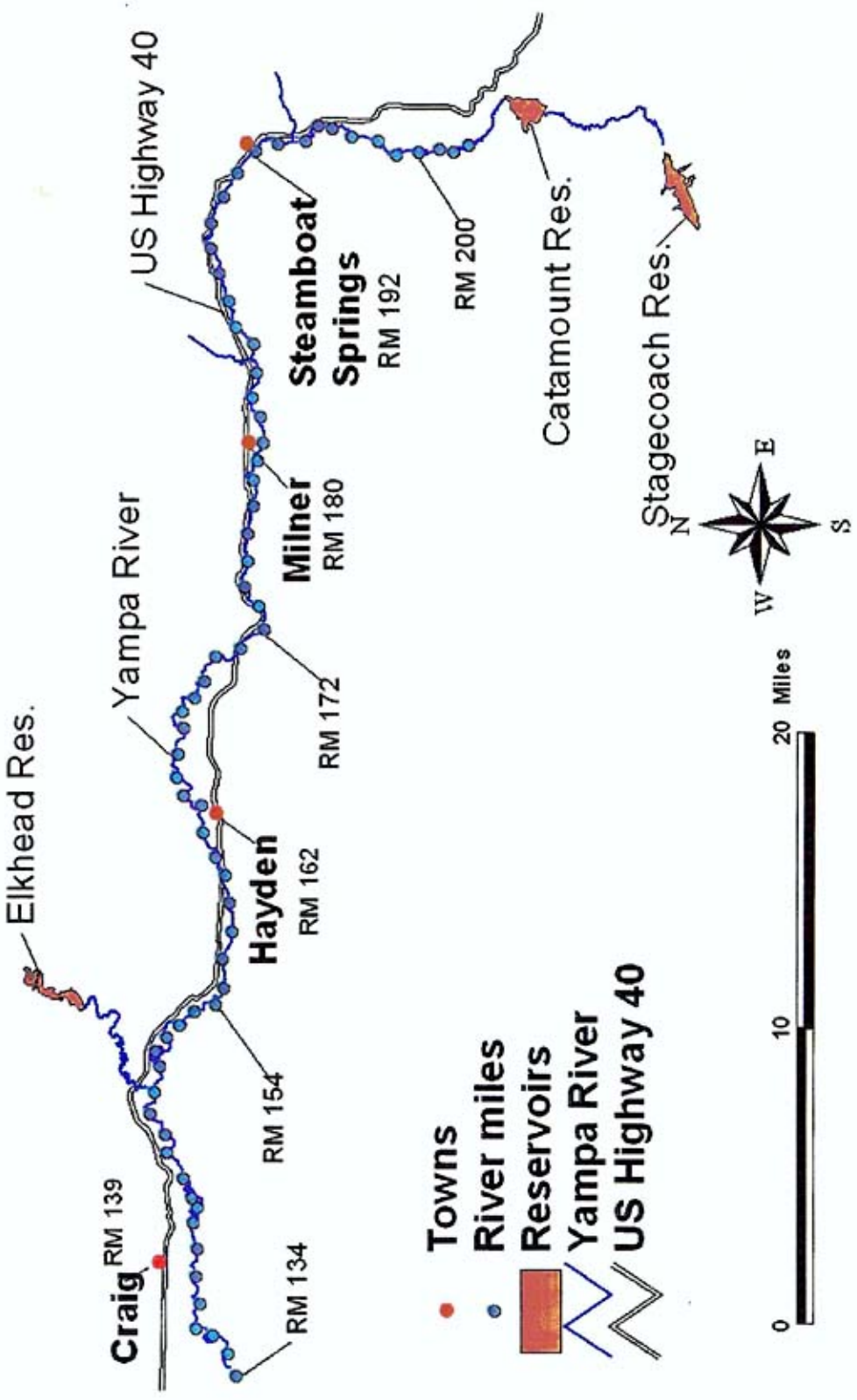
Study Area Maps

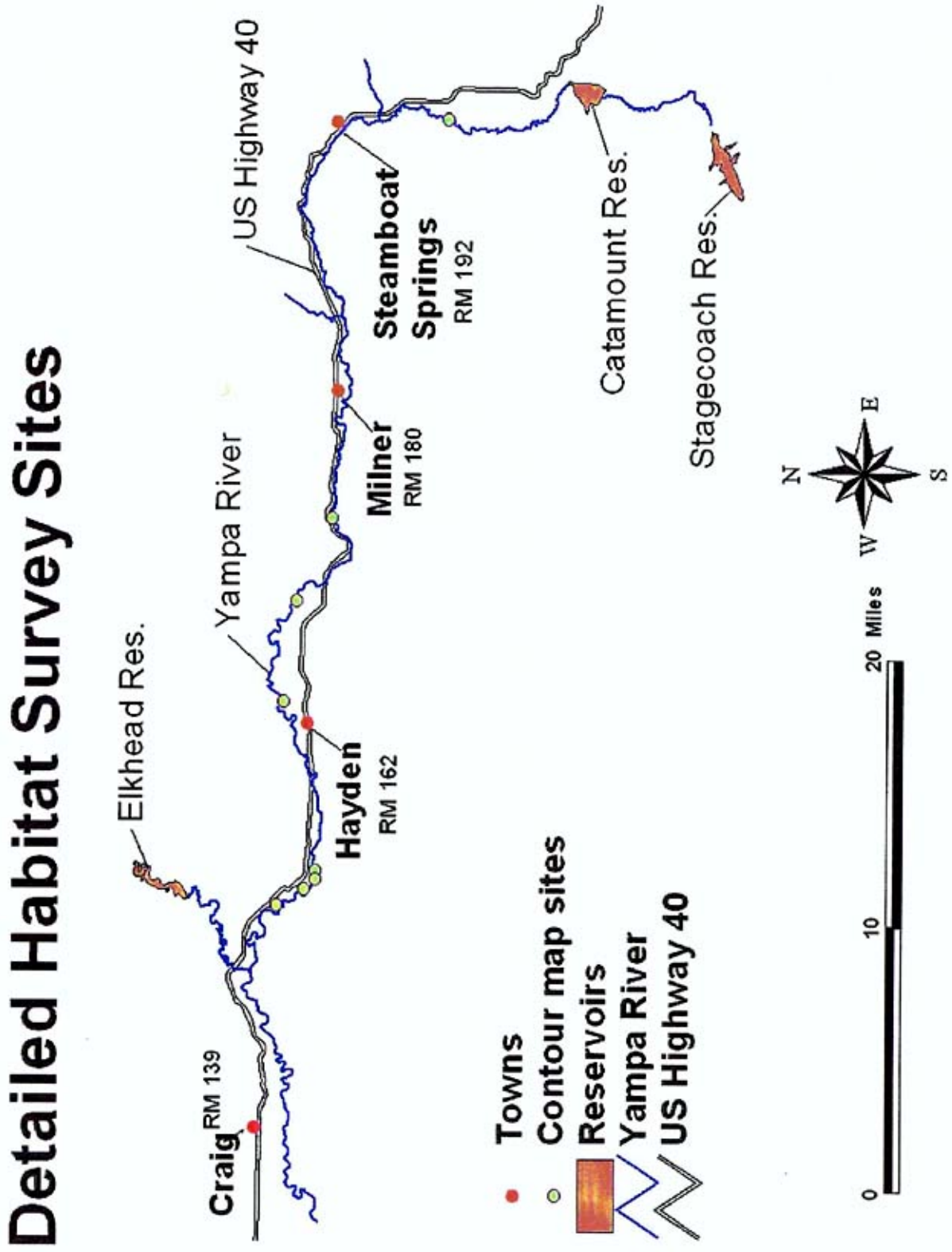
Appendix F: Included are maps of the study area created in ESRI Arcview 3.3 that display the locations of major landmarks, USGS gage stations, river mile measurements, locations of backwaters, and the locations where different aspects of the study took place. All of this data is in the form of GIS shapefiles, therefore, all of this information is really meant to be used in a GIS computer program and is much more useful in that format. Displaying the information as paper maps is primarily a means to communicate the type of information that was collected.

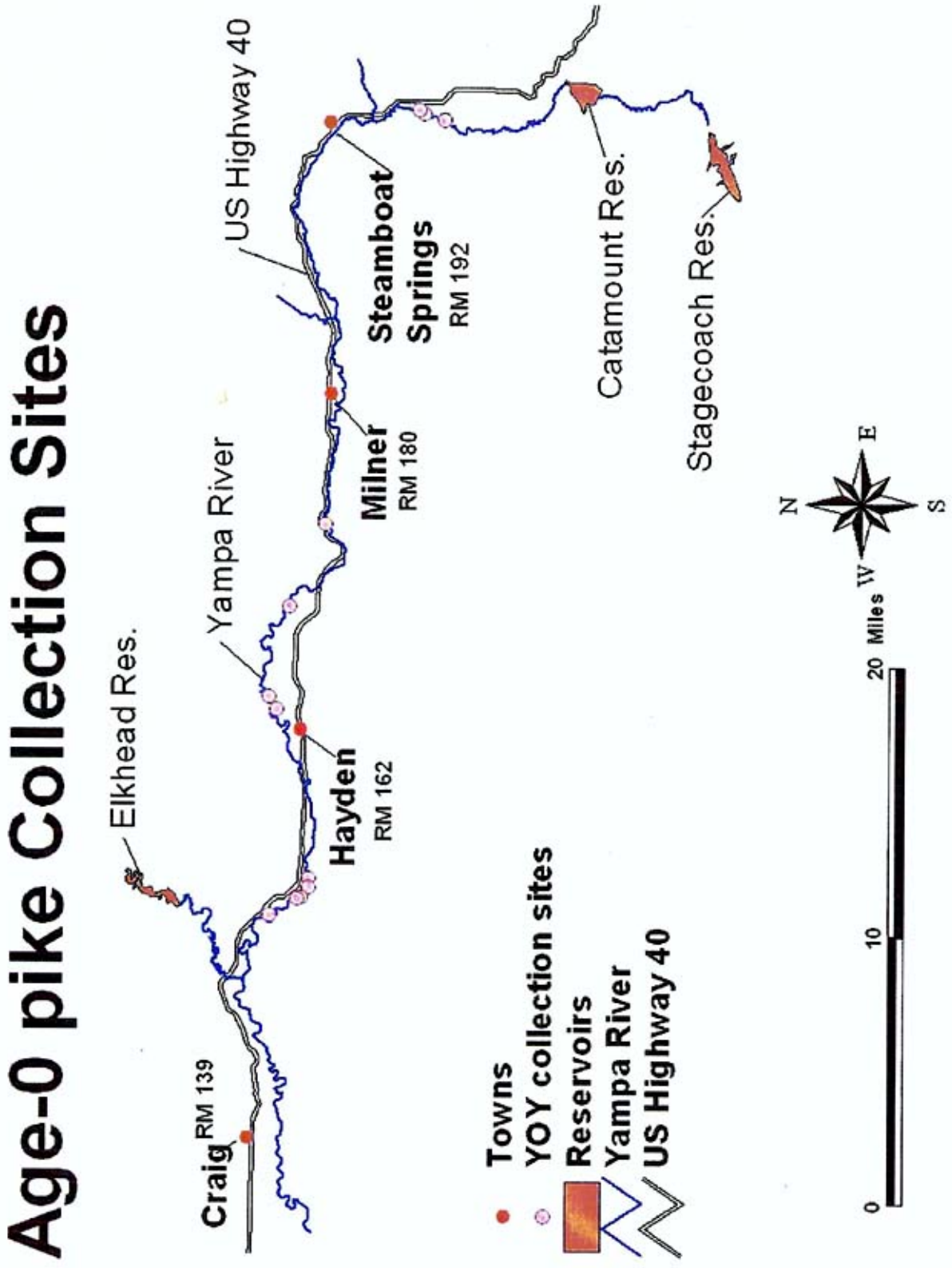

Study Area
Elkhead Res.
Yampa River
US Highway 40
Steamboat Springs
RM 192
Milner
RM 180
Hayden
RM 162
Craig
RM 139
Catamount Res.
Stagecoach Res.
N
E
S
W
Towns
Usgs gage stations
Reservoirs
Yampa River
US Highway 40
0
10
20 Miles


Backwater Spawning Habitat
US Highway 40
Elkhead Res.
Yampa River
Steamboat Springs
RM 192
Milner
RM 180
Hayden
RM 162
Craig
RM 139
Catamount Res.
Stagecoach Res.
N
E
S
W
Towns
Potential spawning habitat
Reservoirs
Yampa River
US Highway 40
0
10
20 Miles

River miles


US Highway 40
Yampa River
Elkhead Res.
Steamboat Springs
RM 192
RM 200
Catamount Res.
Stagecoach Res.
Milner
RM 180
RM 172
Hayden
RM 162
RM 154
Craig
RM 139
RM 134
N
E
S
W
Towns
River miles
Reservoirs
Yampa River
US Highway 40
0
10
20 Miles


Detailed Habitat Survey Sites
Elkhead Res.
Yampa River
US Highway 40
Steamboat Springs
RM 192
Milner
RM 180
Hayden
RM 162
Craig
RM 139
Catamount Res.
Stagecoach Res.
Towns
Contour map sites
Reservoirs
Yampa River
US Highway 40
N
E
S
W
0
10
20 Miles

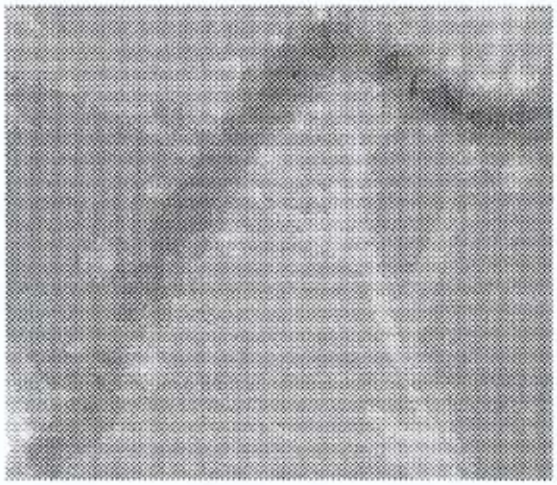

Age-0 pike Collection Sites
Elkhead Res.
Yampa River
US Highway 40
Steamboat Springs
RM 192
Milner
RM 180
Hayden
RM 162
Craig
RM 139
Catamount Res.
Stagecoach Res.
Towns
YOY collection sites
Reservoirs
Yampa River
US Highway 40
N
E
S
W
0
10
20 Miles

APPENDIX G:

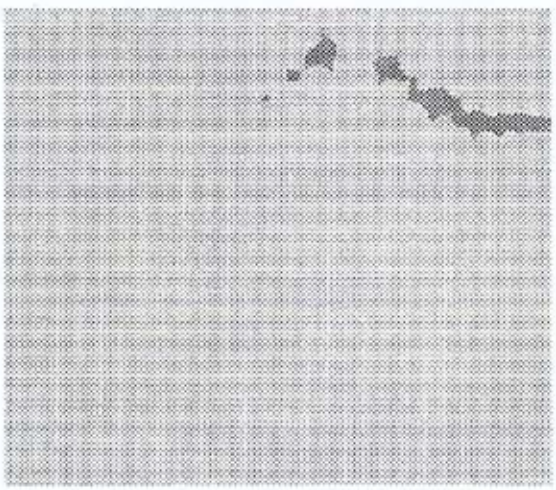
Backwater Wetted Area Maps

Contour maps of backwaters were created to determine the changes in backwater size associated with the increasing flows during the spring and to evaluate the effect different spring runoff intensities could have on backwater habitat. A depth vs. flow relationship was calculated for each of the nine backwaters that we investigated. Each of the nine backwaters were surveyed and the survey measurements were converted into a contour map with Arcview Spatial Analyst. The depth vs. flow information was combined with the contour map to determine the total wetted area in the backwater during a specific river flow. We used the average flow for April 1-15 for 2002 and 2003 to determine the wetted area of the backwater during the primary spawning period. We used the peak flow for 2002 and 2003 to determine whether the backwater connected to the main channel at more than one point and had the potential to have flushing flows. The flows used to calculate the area are reported as cubic feet per second (cfs). The contour map shows the deeper sections in darker colors. The backwater images show the wetted area in dark gray and the dry ground in light gray.

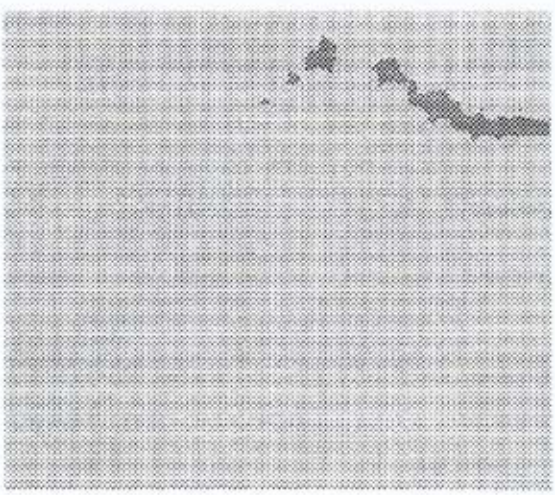
Site at Rivermile 197.8 A



The contour map created for this site. The backwater connects to the mouth of the river at this side.

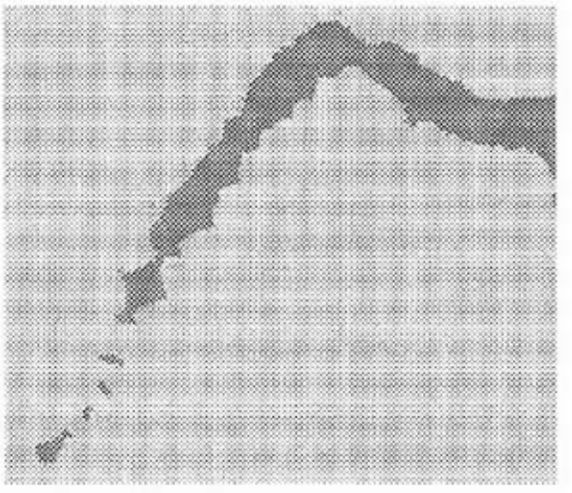


In 2002, the wetted area for April 1-15 was 3,573 ft^2 based on an average flow of 268 cfs for this time period.

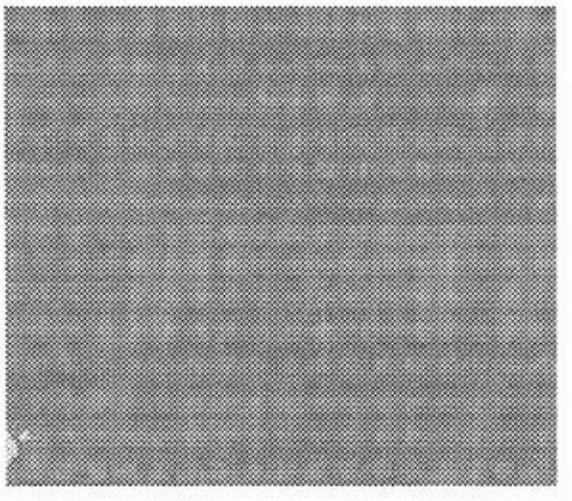


In 2003, the wetted area for April 1-15 was 3,587 ft^2 based on an average flow of 269 cfs for this time period.

Site at Rivermile 197.8 A



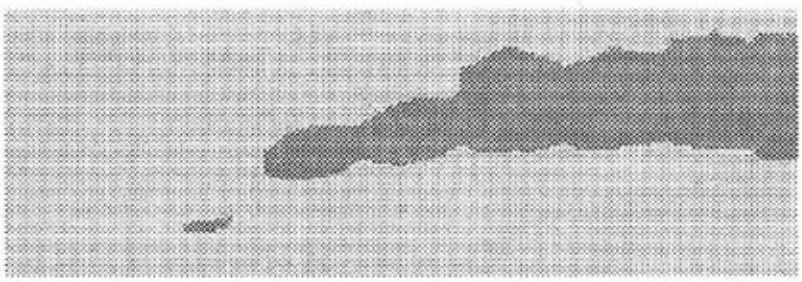
The wetted area at the peak flow of 2002 was 20,385 ft^2. The peak flow was 849 cfs on 5/31.



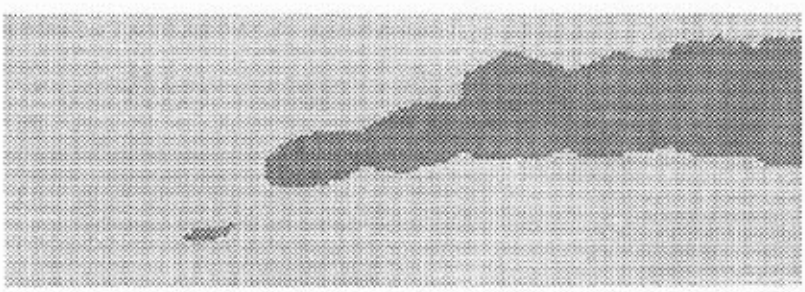
During the peak flow of 2003 the backwater was flooded within the area we surveyed. The backwater at this site was separated from the main river channel by backwater 197.8, B so this site did not receive flushing flows even though it was flooded. The peak flow was 3,678 cfs on 6/1.

Site at Rivermile 197.8 B

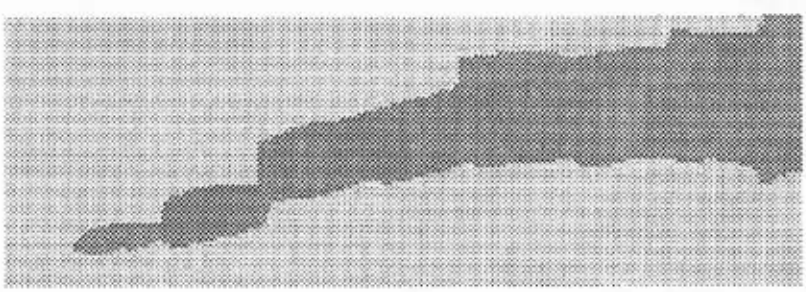
The contour map created for this site. The backwater connects to the mouth of the river at this side.



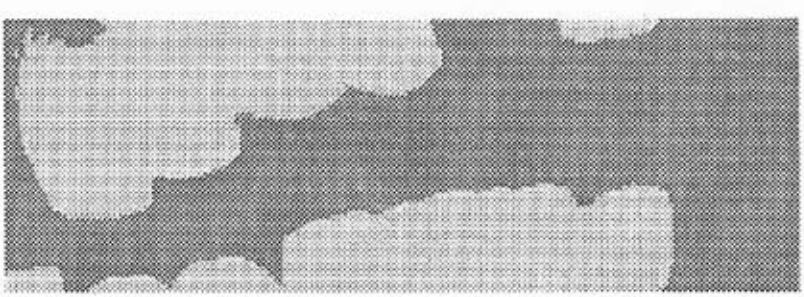
In 2002, the wetted area for April 1-15 was 6,287 ft^2 based on an average flow of 268 cfs for this time period.



In 2003, the wetted area for April 1-15 was 6,287 ft^2 based on an average flow of 269 cfs for this time period.

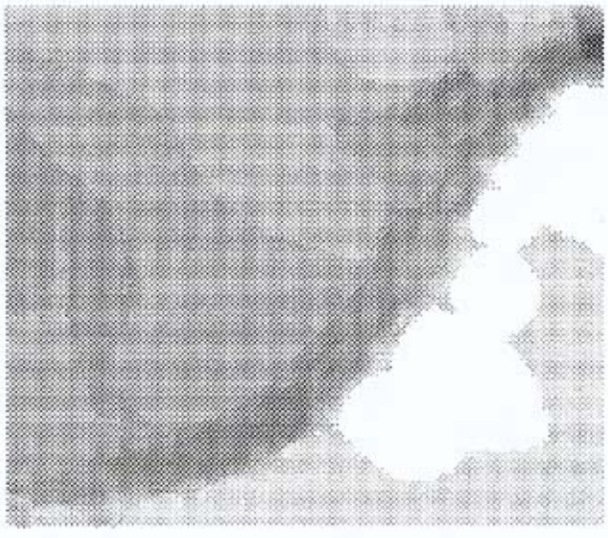


The wetted area at the peak flow of 2002 was 8,789 ft^2. The peak flow was 894 cfs on 5/31.

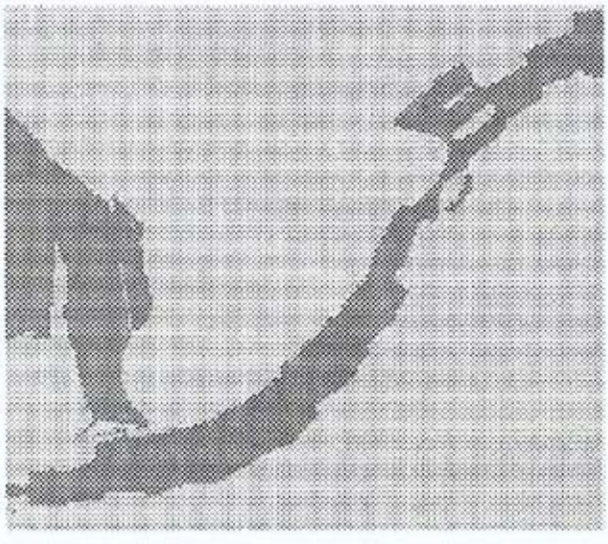


The wetted area at the peak flow of 2003 was 16,583 ft^2. The peak flow was 3,678 cfs on 6/1. There are possible signs of connection to the main channel at the back, although no connection was ever observed.

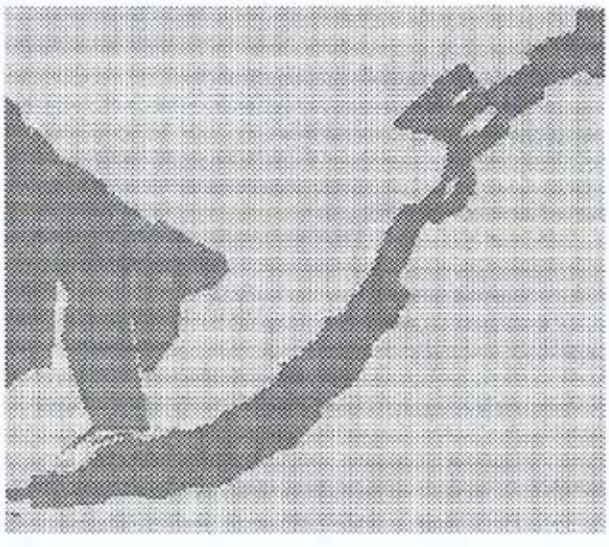
Site at Rivermile 174



The contour map created for this site. The backwater connects to the mouth of the river at this side.

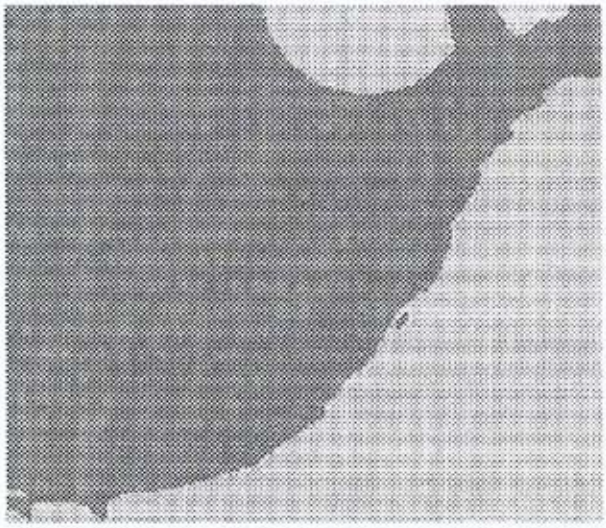


In 2002, the wetted area for April 1-15 was 36,261 ft^2 based on an average flow of 788 cfs for this time period.

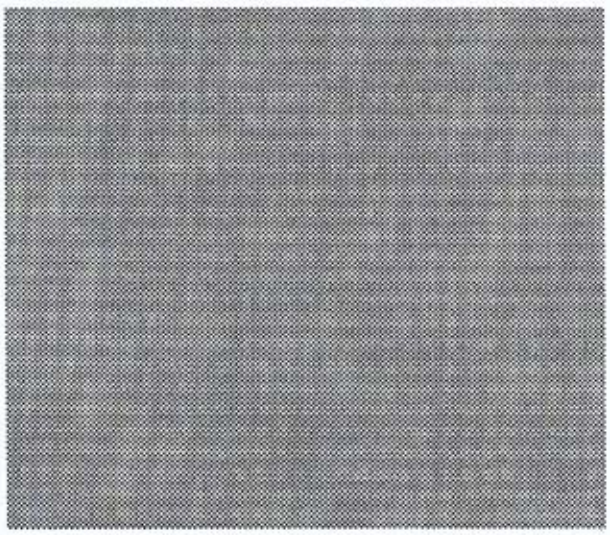


In 2003, the wetted area for April 1-15 was 39,150 ft^2 based on an average flow of 903 cfs for this time period.

Site at Rivermile 174

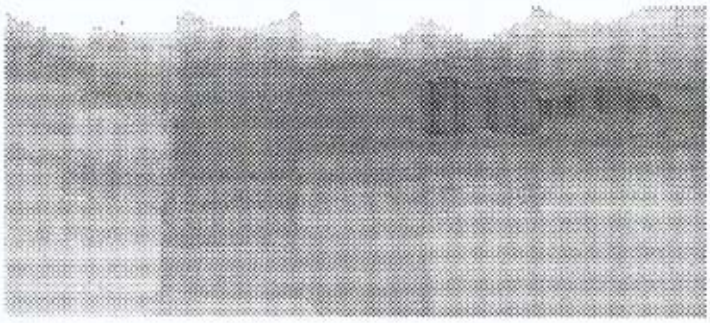


The wetted area at the peak flow of 2002 was 198,635 ft2. The peak flow was 2,961 cfs on 5/31.

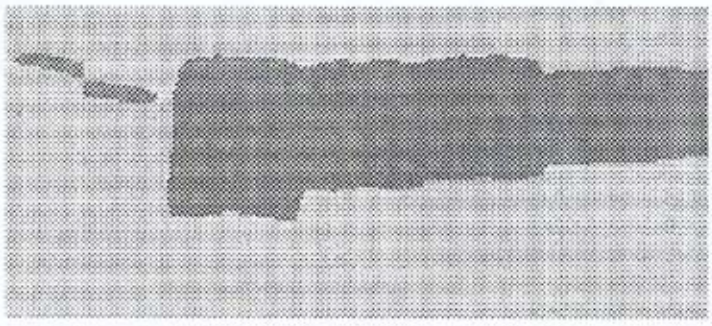


During the peak flow of 2003 the backwater was flooded. The peak flow was 9,757 cfs on 6/1.

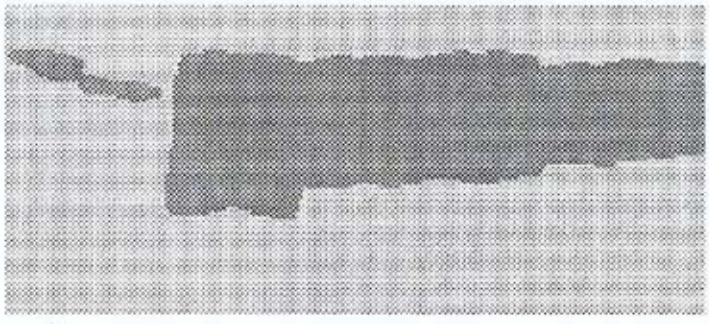
Site at Rivermile 169.1



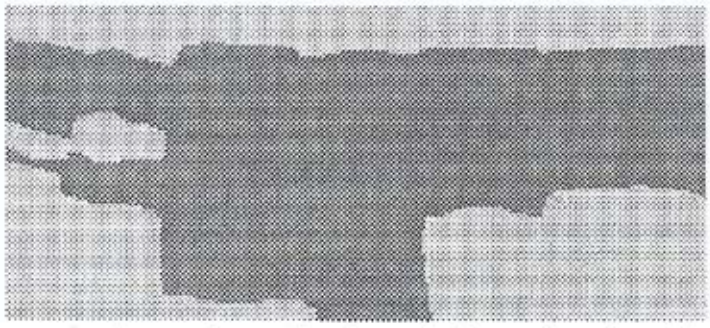
The contour map created for this site. The backwater connects to the mouth of the river at this side.



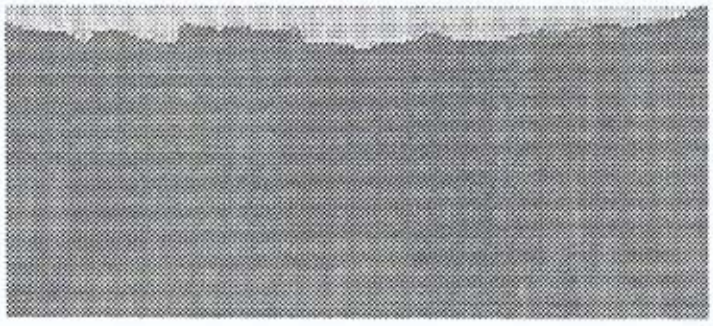
In 2002, the wetted area for April 1-15 was 11,617 ft^2 based on an average flow of 819 cfs for this time period.



In 2003, the wetted area for April 1-15 was 12,209 ft^2 based on an average flow of 947 cfs for this time period.



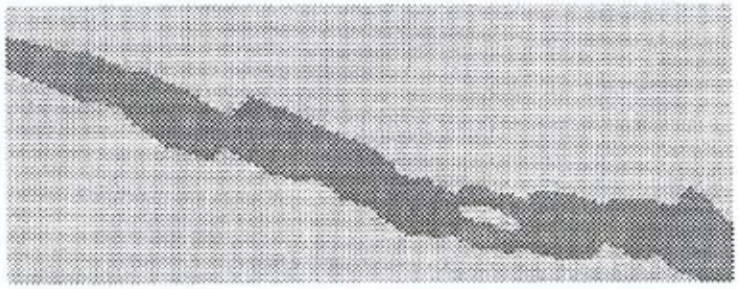
The wetted area at the peak flow of 2002 was 21,712 ft^2. The peak flow was 2,976 cfs on 6/1. This backwater showed a possible connection to the main channel along the edge, shown at the bottom of this image.



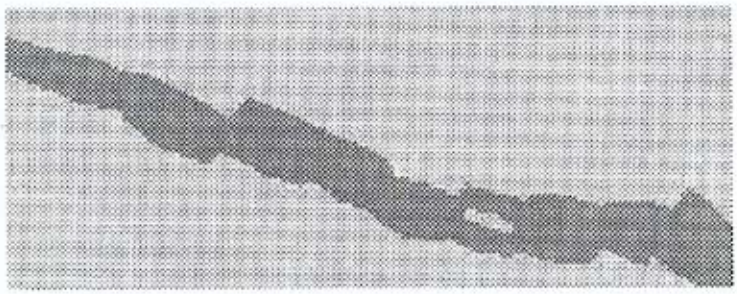
During the peak flow of 2003 the backwater was flooded. The peak flow was 10,065 cfs on 6/1.

Site at Rivermile 163.3

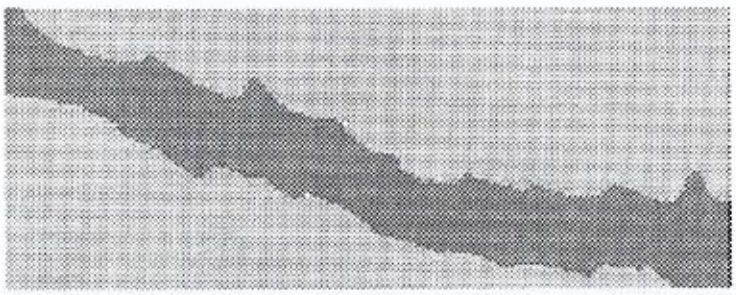
The contour map created for this site. The backwater connects to the mouth of the river at this side.



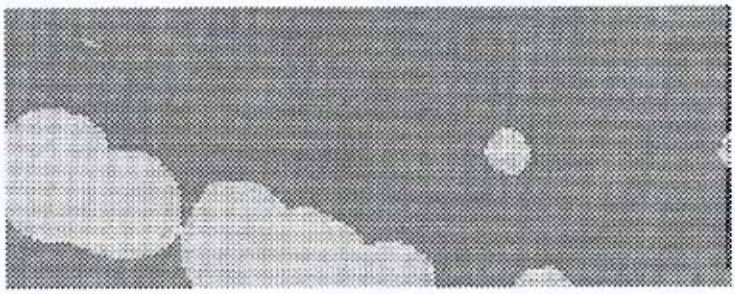
In 2002, the wetted area for April 1-15 was 18,383 ft^2 based on an average flow of 856 cfs for this time period.



In 2003, the wetted area for April 1-15 was 18,961 ft^2 based on an average flow of 1,000 cfs for this time period.

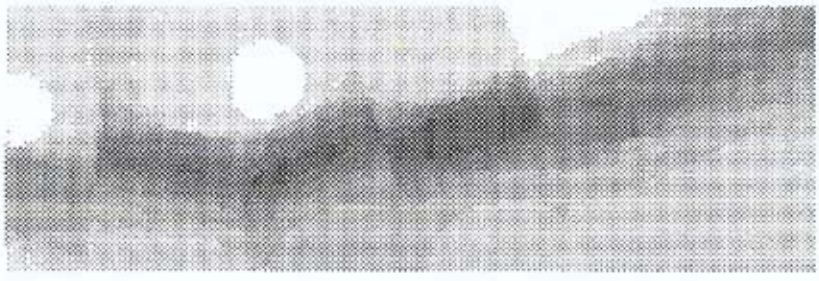


The wetted area at the peak flow of 2002 was 25,703 ft^2. The peak flow was 3,025 cfs on 6/1.

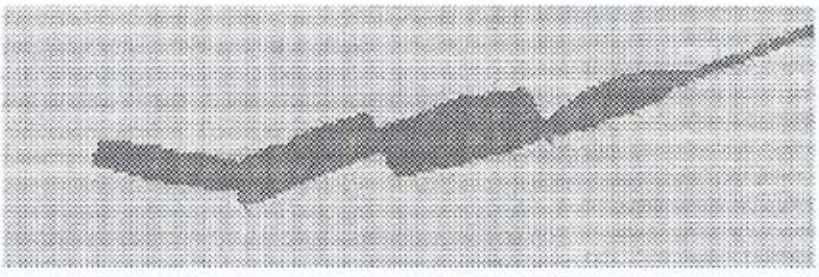


During the peak flow of 2003 the backwater was flooded. The peak flow was 10,065 cfs on 6/2.

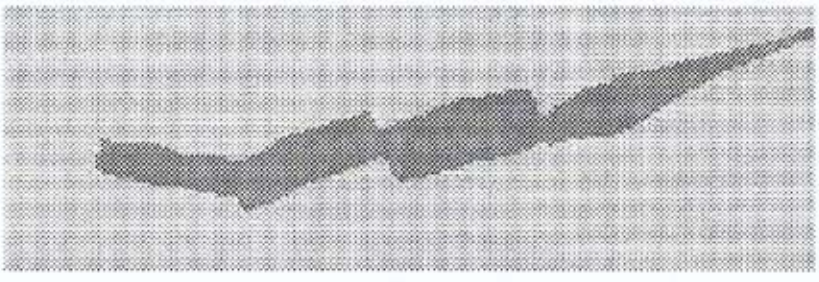
Site at Rivermile 155.3



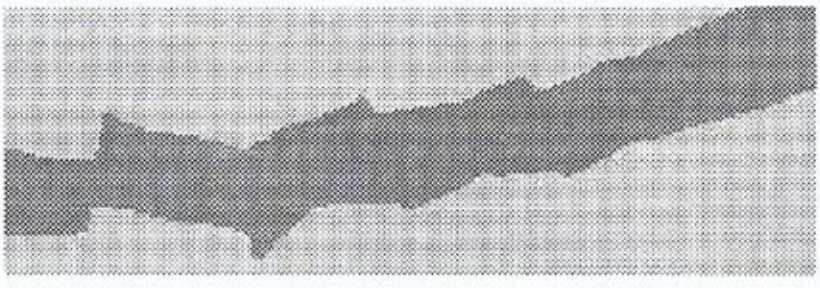
The contour map created for this site. The backwater connects to the mouth of the river at this side.



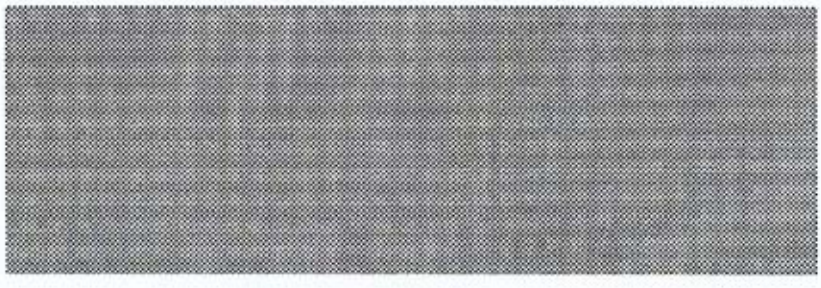
In 2002, the wetted area for April 1-15 was 2,468 ft^2 based on an average flow of 907 cfs for this time period.



In 2003, the wetted area for April 1-15 was 2,872 ft^2 based on an average flow of 1,073 cfs for this time period.

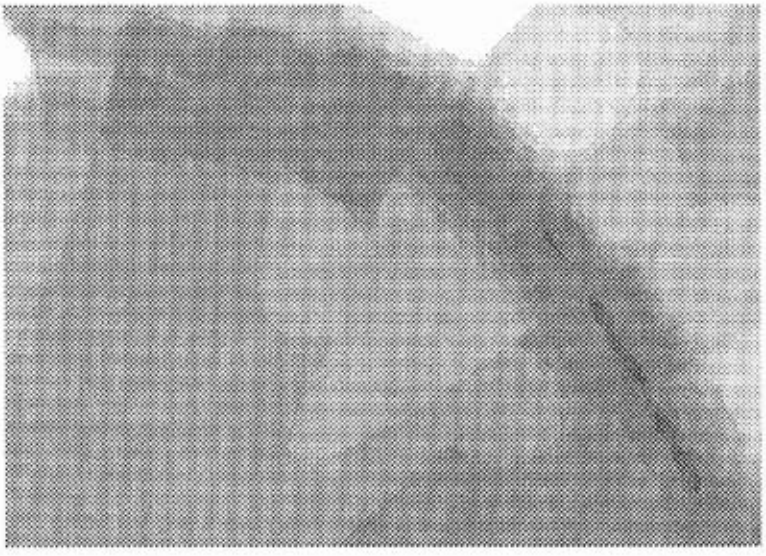


The wetted area at the peak flow of 2002 was 6,700 ft^2. The peak flow was 3,093 cfs on 6/1.

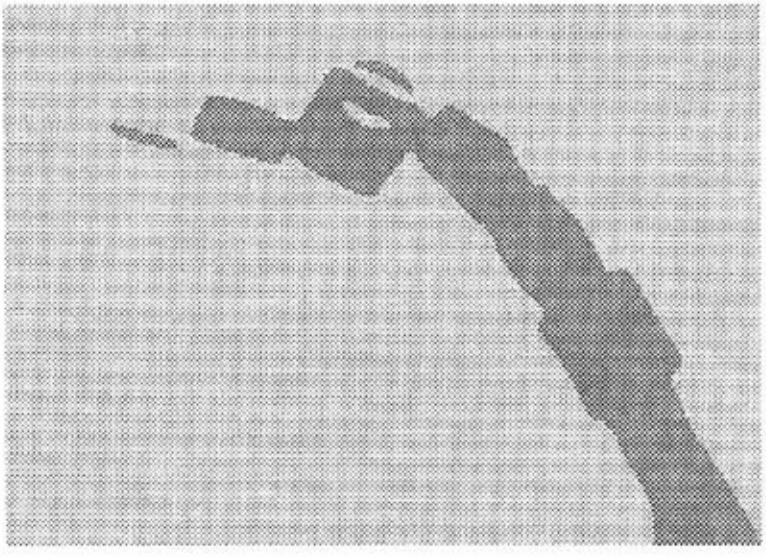


During the peak flow of 2003 the backwater was flooded. The peak flow was 10,434 cfs on 6/2.

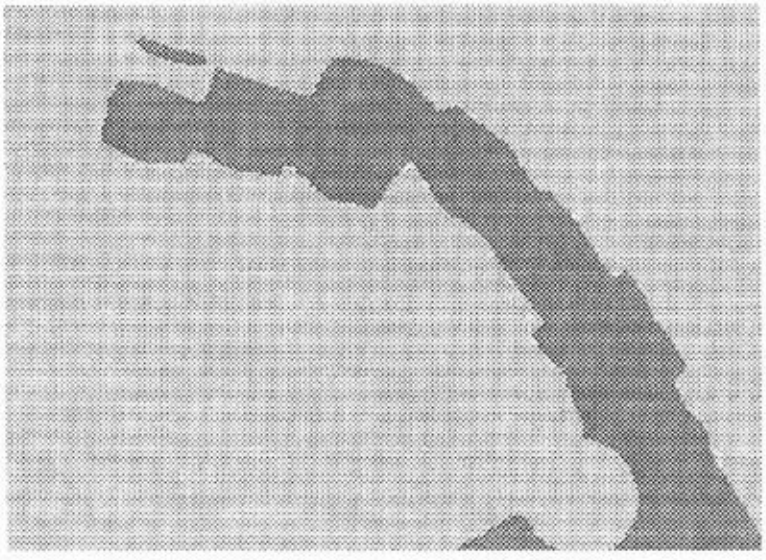
Site at Rivermile 155



The contour map created for this site. The backwater connects to the mouth of the river at the bottom right-hand corner.

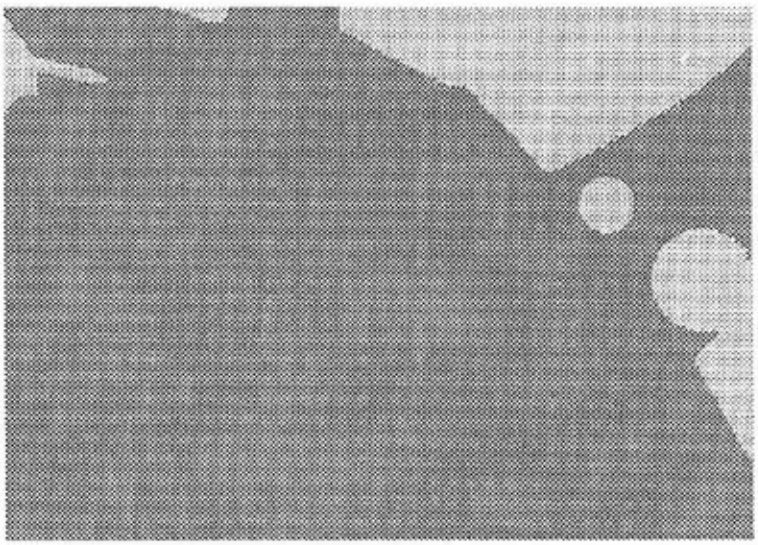


In 2002, the wetted area for April 1-15 was 14,911 ft^2 based on an average flow of 909 cfs for this time period.

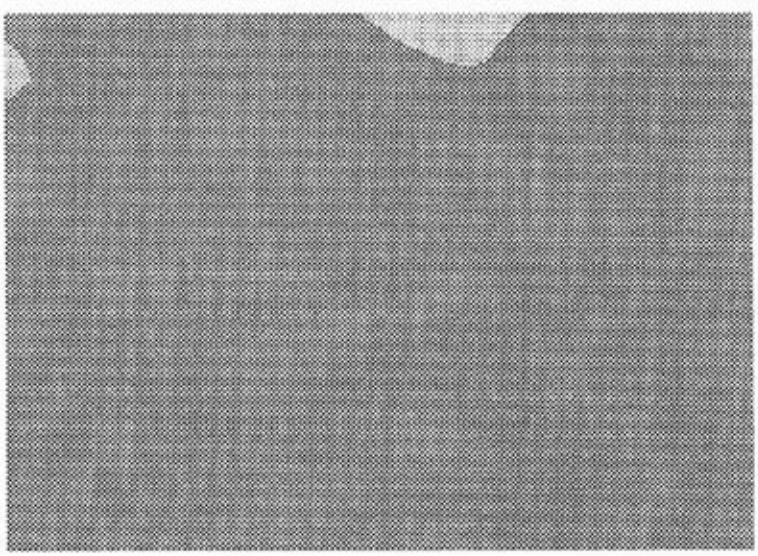


In 2003, the wetted area for April 1-15 was 20,205 ft^2 based on an average flow of 1,076 cfs for this time period.

Site at Rivermile 155



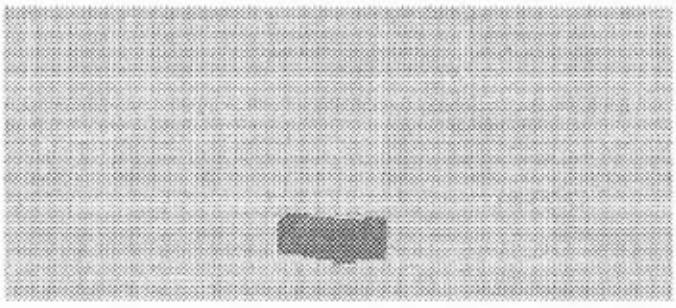
During the peak flow of 2002 the backwater was flooded. The peak flow was 3,096 cfs on 6/1.



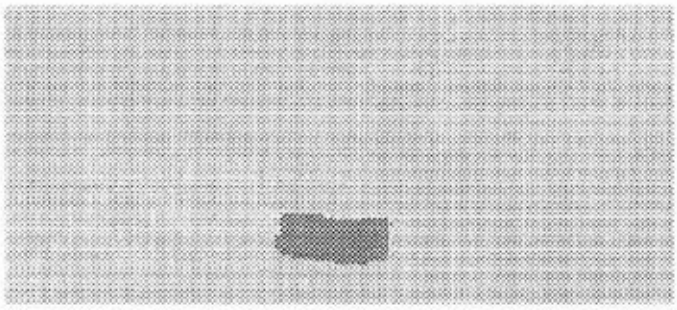
During the peak flow of 2003 the backwater was flooded. The peak flow was 10,448 cfs on 6/2.

Site at Rivermile 154.2

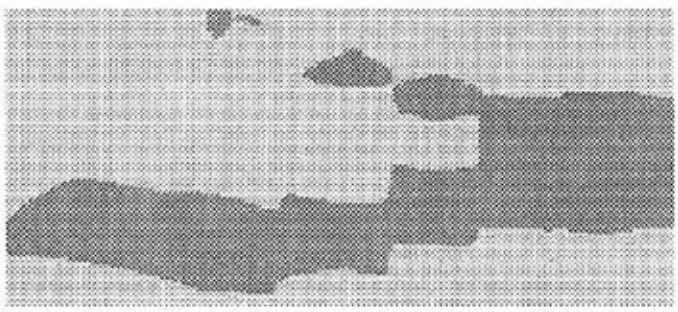
The contour map created for this site. The backwater connects to the mouth of the river at this side.



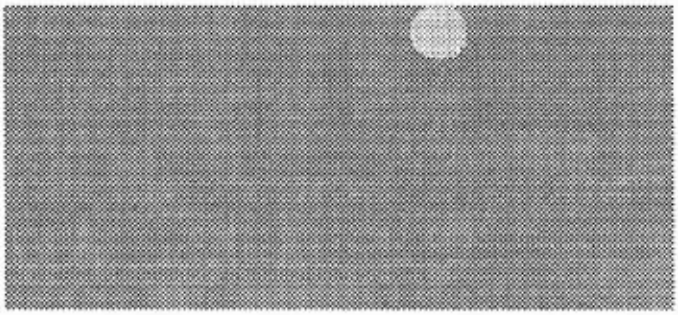
In 2002, the wetted area for April 1-15 was 2,069 ft^2 based on an average flow of 914 cfs for this time period.



In 2003, the wetted area for April1-15 was 2,162 ft^2 based on an average flow of 1,083 cfs for this time period.

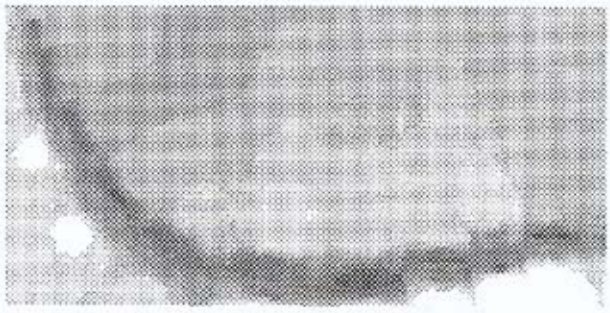


The wetted area at the peak flow of 2002 was 31,354 ft^2. The peak flow was 3,102 cfs on 6/1. This image shows a possible connection to the main channel at the back of the backwater.

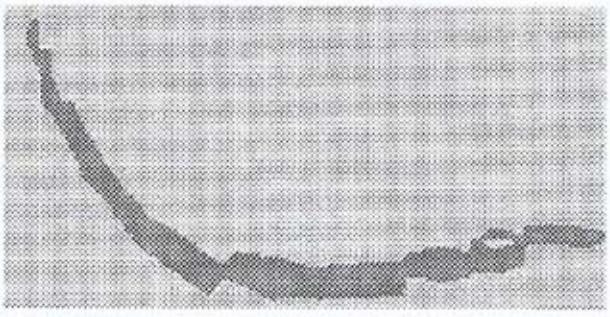


During the peak flow of 2003 the backwater was flooded. The peak flow was 10,481 cfs on 6/2.

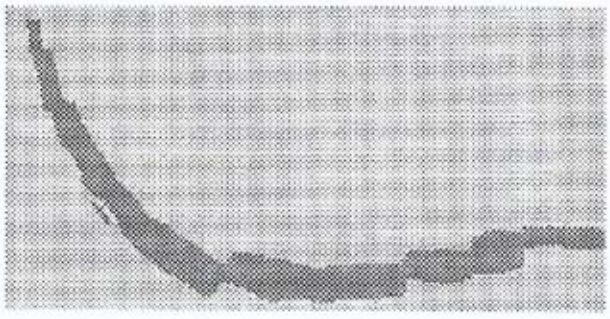
Site at Rivermile 152.5



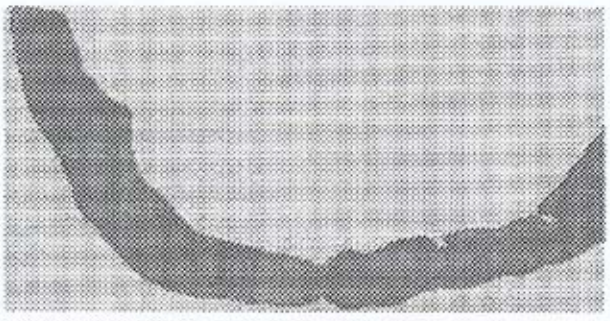
The contour map created for this site. The backwater connects to the mouth of the river at this side.



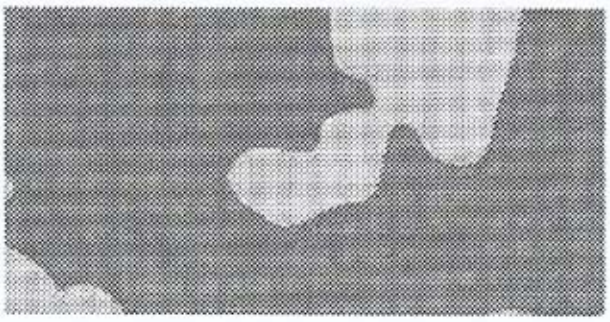
In 2002, the wetted area for April 1-15 was 28,290 ft^2 based on an average flow of 924 cfs for this time period.



In 2003, the wetted area for April 1-15 was 31,691 ft^2 based on an average flow of 1,098 cfs for this time period.



The wetted area at the peak flow of 2002 was 67,075 ft^2. The peak flow was 3,115 cfs on 6/1.



During the peak flow of 2003 the backwater was flooded. The peak flow was 10,555 cfs on 6/2.